DISEASE AND HEALING IN THE INDUS CIVILISATION

Robert Arnott

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For Tricia

"All interest in disease and death is only another expression of interest in life."

Thomas Mann
The Magic Mountain (1924)

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Introduction

The Indus was the most extensive urban Bronze Age civilisation of its time. That part of South Asia with which it is associated is estimated to be approximately 1,500,000 km^2 in size (Figure 1). During its Mature Harappan (or Urban) Phase, which lasted from *c.* 2600 to 1900 BC, this complex urban civilisation supported *c.* 1500 sites, ranging from village-farming communities and small towns up to several fully developed and wealthy urban complexes or cities, supporting populations of tens of thousands or likely many more. Its influence was seen far beyond its northern borders, up to what is now modern Tajikistan and as far to the west as the Gulf and Mesopotamia. Indus Civilisation urban buildings consisted of warehouses, massive city walls, gateways, a public health infrastructure, brick-built houses, and extensive areas for craft and industrial production. There were seemingly no palaces or other areas reserved for the use of elites.

The Indus Civilisation is associated with two great rivers, the Indus and the Ghaggar-Hakra, the latter now almost completely dried up. In prehistory, they ran virtually parallel to each other, creating a vast alluvial plain that supported the region's agricultural base, both arable and pastoral.

Supplying the demands for food, raw materials, and finished products, required a sophisticated infrastructure that integrated the widely dispersed settlements. Consequently, many of the specialist craft products became standardised and widely distributed throughout the region. Close similarities in pottery, brick sizes, seals, weights and measures, together with the Indus script, show convincing evidence for a shared ideology and suggest the existence of some form of administrative system to oversee the economy, especially food production and overseas trade.

The appearance of the Mature Harappan Phase of the Indus Civilisation was originally thought to represent the result of cultural diffusion and acculturation from the Near East, but this has now been discredited by the discovery of a structured subsistence economy and proto-urbanisation in the Pre- and Early Harappan Phases in the 5th to 3rd millennia BC. This developed directly from the Aceramic Neolithic that had begun in the 7th millennium BC in such centres as Mehrgarh in Western Baluchistan, and shows a slow and completely indigenous development of their society and cultures from earlier prehistory.

Yet the very existence of this Bronze Age civilisation was unknown until 20 September 1924. It was then that Sir John Marshall, the British Raj's Director-General of Archaeology in India, announced its discovery in the *Illustrated London News*, in an article appropriately titled 'First Light on a Long-Forgotten Civilisation' following excavations by his Indian colleagues at the sites of Harappa (Figure 2) and Mohenjo-daro. Until 1924, it was thought by most scholars that before the 6th century BC, India was a cultural and historical backwater. The discovery of the Indus Civilisation changed all that. Since then, archaeological research centred on modern

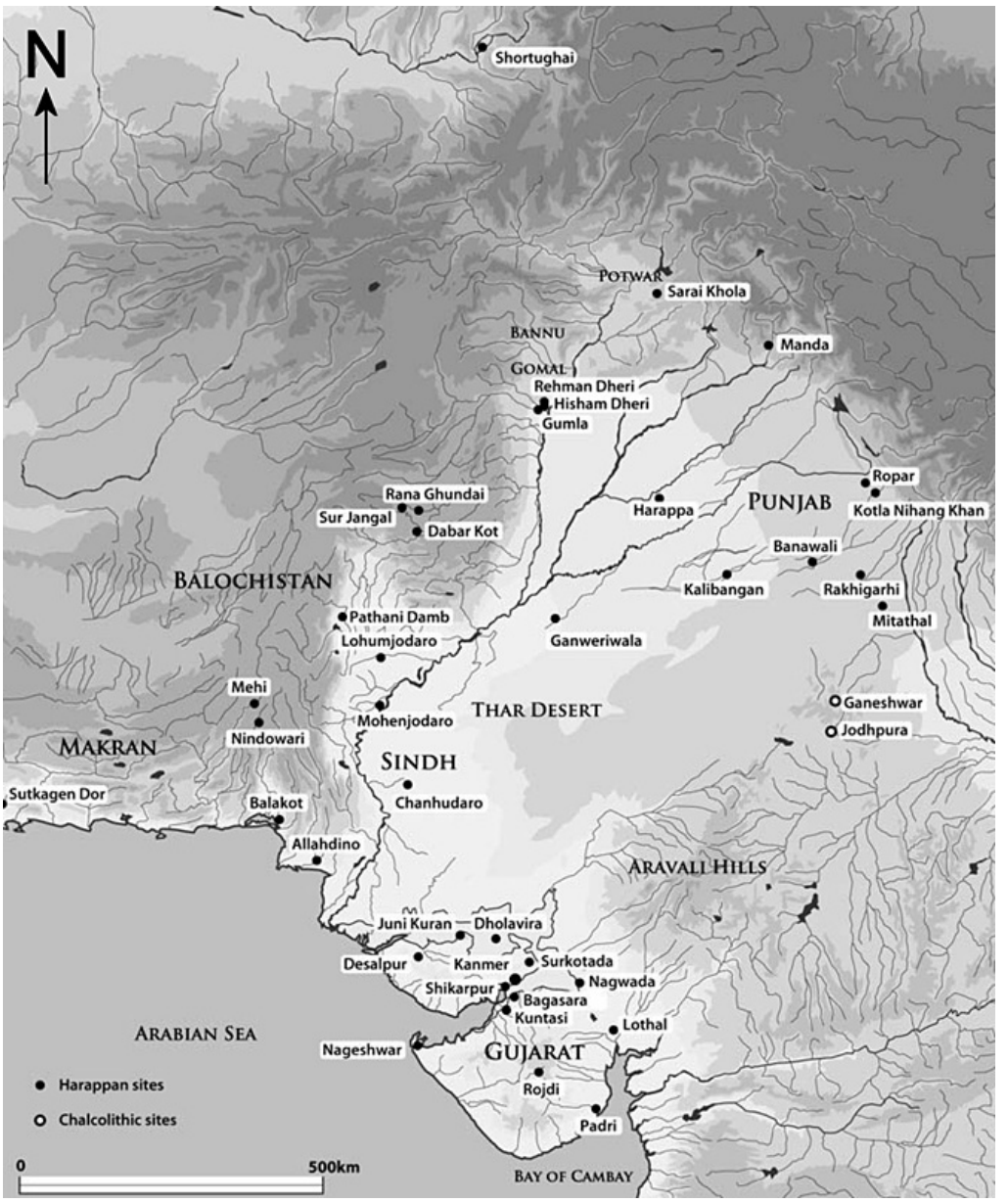

Figure 1. Map of principal Indus Civilisation sites (after A. Uesugi, University of Wisconsin-Madison).

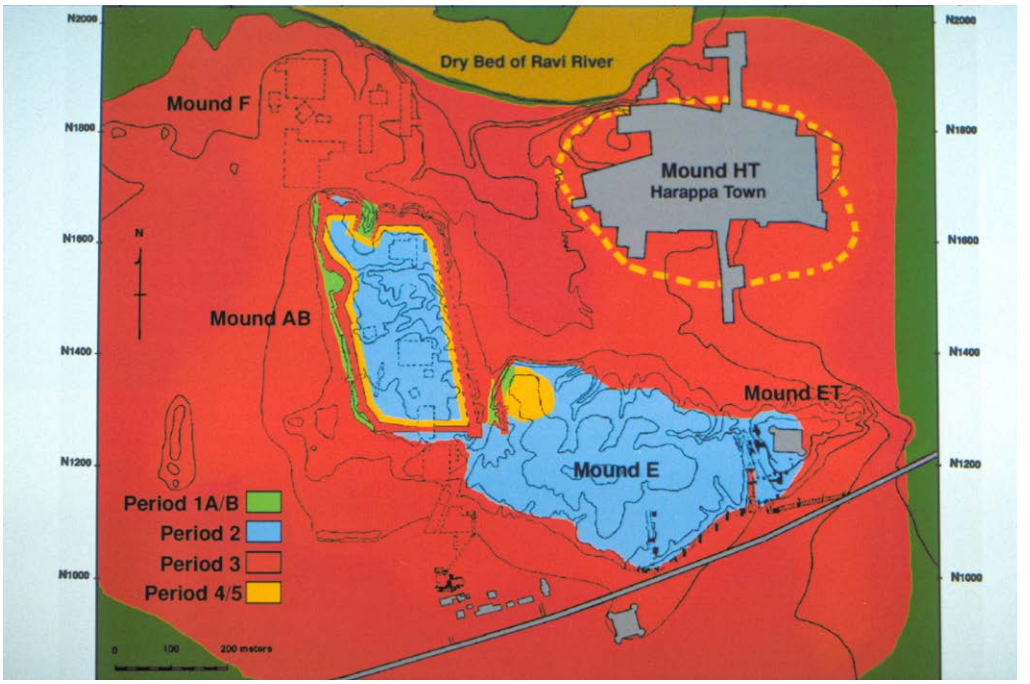

Figure 2. Harappa site plan showing phases of occupation (© Harappa Archaeological Research Project).

India and Pakistan, and even further afield in the Gulf, Central Asia and the Near East, has been constantly expanding our knowledge.[1]

Earlier Work

Earlier work on healing and medicine in the Indus Civilisation has largely been centred on the archaeological remains of major public health infrastructures, such as that of Henry Sigerist in volume two of his sadly incomplete *A History of Medicine*,[2] where he refers to some of the architecture of the 'Great Bath' and sanitation unearthed at Mohenjo-daro. In the introduction to her *A History of Medicine in Ancient India (From Antiquity to 1000 AD)*, Priya Sharma provides a few facts about sanitation, but introduces nothing that is not already known.[3] Earlier work also includes references to animal- and mineral-based medical remedies described by Sir John Marshall in his monumental *Mohenjo-daro and the Indus Civilisation*.[4]

In his review of the history of early Indian medicine, Dominik Wujastyk, who, while again commenting on the public health infrastructure of the Indus Civilisation, particularly the

[1] Gregory Possehl has outlined the recent history and historiography of the archaeology of the Indus Civilisation up to the turn of the century (see Possehl, G.L. Fifty years of Harappan Archaeology: the study of Indus Civilisation since Indian independence, in *Retrospect*: 1-46).

[2] Sigerist, H.E. 1961. *A History of Medicine*, Volume II, *Early Greek, Hindu and Persian Medicine*: 137-145. Oxford: Oxford University Press.

[3] Sharma, P.V. (ed.) 1992. *History of Medicine in India (from antiquity to 1000 AD)*: 8-14. New Delhi: Indian National Science Academy.

[4] *Mohenjo-daro*: 29, 587-588, 669, 671-672.

Great Bath at Mohenjo-daro, and lamenting that the Indus script is unable to offer any clues to their healing, does suggest that healers existed, also acting as religious functionaries. He also comments on the identification of images of the pipal or sacred fig leaf, also known from Ayurvedic medicine.[5] The therapeutic value of the pipal tree in prehistory was also speculated on by Raymond and Bridget Allchin.[6]

Of other historians of ancient Indian medicine, only Kenneth K. Zysk in his *Religious Medicine: The History and Evolution of Indian Medicine* attempts to reconstruct Indus Civilisation medicine and public health and in doing so also properly recognises the importance of understanding the relationship between healing and religion.[7]

In a more recent work, Subhrajit Paul *et al.* curiously refer to an Indus Civilisation health system. However, much of it is fantasy, with the reference to 'documents from Mohenjo-daro', which, according to them, describe 960 medicinal plants; they also allegedly offer information on anatomy, physiology, pathology, and obstetrics.[8] Where their evidence comes from is beyond a mystery.

Subhash Walimbe has briefly examined the history of medicine in the period, starting with the view that it would be interesting to see the correlation of Indus Civilisation morbidity and the development of medicine in India; he is not convinced that increasing morbidity experienced by the population gave any impetus to development of medicine. The author rightly believes that the earliest Vedic texts, which can be positively dated to no earlier than 1500 BC, indicate that the practice of medicine had not yet developed into an independent profession; it was a part of the functions of the priest-physician, and basically magico-religious in character.[9]

Human Skeletal Remains: Problems and Challenges

The results of the study of the skeletal evidence from the Indus Civilisation up to 2002 have been summarised by G.L. Possehl *et al.*[10] and some of this evidence is also included in a short article by Bhan and Dahiya.[11] Since 2002, much more has been published and details are referred to in later chapters of this book. Indus healing or medicine, however, has not been an area covered by any of those who have led the way in studying the human remains. All of this points to the need for this book. A more recent review of the evidence in India of human

[5] Wujastyk, D. 1993. Indian Medicine, in W.F. Bynum and R. Porter (eds) *Companion Encyclopaedia of the History of Medicine*: 755-780, especially 755-756. London; Routledge.

[6] *Rise of Civilisation*: 134, 148, 163, 211, 214-215.

[7] Zysk, K.G. 1993 *Religious Medicine: the history and evolution of Indian medicine*. New Brunswick: Transaction Publishers (revised version of Religious Healing in the Veda' Transactions of the American Philosophical Society 1985, 75(7): 1-311, especially 1-4).

[8] Paul, S. *et al.* 2019 'Pre-vedic medicinal systems in India. *Recent Chronicle in Health Sciences* 5: 1-4. There are also those who try and associate Rudra-Shiva, the Vedic physician and so-called 'immunologist' with the Indus Civilisation, in an assertion that the Vedic Culture belongs to that period, see Pal, R. 2019. *Rudra-shiva the Vaidika physician and Manu the sacrifice - a study of science and culture in Bronze-Age India.* New Delhi: [PUBLISHER??}

[9] *Walimbe*: 115.

[10] *Contemporary Perspective*: 157-176. This review does not include the newer work of G.R. Schug and her colleagues, who are beginning to transform much of our knowledge of Indus life and death from the skeletal record, see *Infection* and *Peaceful Realm?*: *passim*. See also V. Mushrif-Tripathy *et al.* Where are they now? The Human Skeletal Remains from India, in G.R. Schug and S.R. Walimbe (eds) *A Companion to South Asia in the Past*: 496-530. Chichester: Wiley.

[11] Bhan, S. and K.S. Dahiya 2001.Disease, Surgery and Health in the Harappan Civilisation, in D. Kumar (ed.) *Disease and Medicine in India: a historical overview*: 3-14. New Delhi, Tulika Books (for Indian History Congress).

skeletal remains and a discussion of its prospects has recently been offered by Walimbe. Here he critically evaluates past work in the field and develops ideas for the future around the need for the application of bioarchaeology to human remains from both past and future excavations.[12]

A surgical procedure for which we do have evidence from the human skeletal remains is cranial trepanation,[13] but it has also been the subject of misinterpretation. For example, Jagat Joshi (2000) in his review of the archaeology of the Indus Civilisation remarked that '[it] appears that the Harappans had a good knowledge of medicine and surgery. Earliest examples of brain surgery are available in this respect. The Harappan burials at Kalibangan and Lothal bear the evidence of trephination, i.e. brain surgery.'[14]

Cranial trepanation in the Indus Civilisation, like elsewhere, is cranial not brain surgery, an especially important distinction. Brain surgery was not attempted by any ancient society and is not even hinted at in any early medical texts. If it had, infection brought on by unsterilised instruments and a lack of anatomical knowledge would have rendered the procedure deadly. Cranial trepanation is an attempt to form holes in the cranial vault for both therapeutic and magico-religious purposes and does not involve the brain or any tissue below the dura mater.[15]

There are no human soft tissue remains in the Indus region so the evidence for disease and trauma is linked solely to the study of the skeletal evidence, largely found in graves. As Ortner and Theobald have reminded us, acute diseases suffered in antiquity, and many that caused death, leave no evidence on bones as observed by macroscopic or microscopic methods or by radiography. Attributing the few diseases and conditions that occur in skeletons to a specific morbid syndrome is therefore difficult and consequently the record has become distorted.[16] We must also take into consideration that the skeletons found at a particular site make up only a very small proportion of the population and may not be wholly representative of that population across two millennia or more of occupation.

A summary of the evidence for disease and trauma in Indus human skeletal remains has again been summarised by Walimbe.[17] He remarks that general or cumulative stress is reflected by higher mortality rates, decreased ages at death, retarded body growth, delicate body, with some diseases leaving more specific indicators of stress on bone and teeth. Infectious disease, caused by viruses, bacteria or parasites, such as tuberculosis and leprosy, or non-specific infectious lesions like periosteal reactions, osteomyelitis, maxillary sinusitis, mastoiditis or inflammation of bone, are included in this category. Traumatic lesions are caused by injury or malformation of the skeleton and associated soft tissue. This category includes fractures, dislocations and artificially induced deformities. Joint disease includes the diseases that affect the joints of the

[12] *Walimbe*: *passim.*
[13] Arnott, R. 2015: 23-34.
[14] Joshi, J. 2000. Harappan Civilization as seen at the close of the twentieth century. *Man and Environment* 25(1): 20. This misinterpretation has also recently been repeated in Sankhyan, A.R. and G. R. Schug 2011. First evidence of brain surgery in Bronze Age Harappa. *Current Science* 100: 1621-1622.
[15] Arnott, R. 2015: 23-34.
[16] *Pre-Roman Diseases*: 247-248. Roberts and Manchester have also outlined the limitations of palaeopathology, see *Disease*[3]: 12-14.
[17] *Walimbe*: 114.

body and their associated soft tissue. These lesions are commonly seen in older individuals, those in degenerative phase and include osteoarthritis, vertebral osteophytosis or vertebral lipping.

He continues his summary stating that metabolic diseases are caused by a disturbance in the normal process of cell metabolism. The most common examples are enamel hypoplasia, i.e. disruption in tooth enamel matrix formation. Porotic hyperostosis, cribra orbitalia and iron deficiency anaemia are also included in this category. Stress factors are occupationally related stress indicators that are caused by repetitive use of certain body parts, resulting in bone remoulding. Squatting facets, clavicle remoulding, evidence for the use of teeth as cutting instruments and asymmetry in long bones are commonly seen examples.

Finally, he goes on to state that neoplastic or new bone formation includes malignant or progressive growth, which invades and destroys surrounding tissues and spreads to more distant sites in the body beneath the skin. A rare example of this category is cancer. Several diseases of teeth and jaw bones are commonly reported in skeletal populations. Dental anomalies or lesions, e.g. wear, caries, tarter accumulation, fluorosis, enamel hypoplasia, alveolar resorption (abscess in jaw bone), premature tooth loss, dental crowding, and asymmetry are all included in this category. The most affected sites on the human skeleton are the cranium, facial bones, and tibia. However, even regardless of the limitations, the evidence that is available is useful and can produce much of what we seek.

In the past, several attempts have been made, through the study of the human skeletal remains, to understand the anthropological affinities of the inhabitants of all phases of the Indus Civilisation and earlier.[18] This is strongly criticised again by Walimbe, who states that before 1980 those involved in skeletal analysis traditionally relied on cranial dimensions for determining population groups. Regarding craniometry as the main tool used in human skeletal research in the Indus Civilisation (and elsewhere), he roundly disparages this approach and states that labelling population groups by crania is highly questionable and limiting. He infers that it does not take into account the relatively few crania so far excavated and that the skeletons represent widely separated geographical, chronological and cultural periods and levels, and include various age-sex groups, obviously diminishing its value.[19] Much of this work, based on the pathological study of crania, has usually been undertaken to try to prove or disprove Indo-Aryan connections with, or even the origins of, the Indus Civilisation.

The study of Indus Civilisation human skeletons has long suffered from the flawed illusion that there are direct correlations between race, language, and culture. However, recent work by archaeologists from the Deccan College Postgraduate and Research Institute, Pune, has used aDNA extracted from human skeletal remains found at Rakhigarhi and elsewhere to properly research the origins of the Indus Civilisation.[20]

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[18] See K. Kennedy's review 'Biological anthropology of human skeletons from Harappa' in *Retrospect*: 293-316. For a debate on the importance or otherwise of using human skeletal remains to determine race and origins, see the antagonist S. Ratnagar's 'Back to Bones?, in *Man and Environment* 1998, 23(2): 101-105 and the protagonists in their responses, with a plea for looking at biological variations and affinities of ancient populations in Kennedy *et al.* 2000. Bring back the bones: the hard evidence. *Man and Environment* 25(1): 105-109; Walimbe, S.R. 2000. Tumults in skeletal biology of the Harappans: response to Ratnagar. *Man and Environment* 25(1): 111-116, and Joglekar, P.P. 2000. Back to Bones – a rejoinder. *Man and Environment* 25(1): 117-118. See also Ratnagar's response in Ratnagar, S. 2000. Reply to Kennedy *et al.*, Walimbe and Joglekar. *Man and Environment* 25(1): 119-120.

[19] *Walimbe*: 105-106.

[20] *Bioarchaeology*: *passim*; Vasant Shinde *et al.* 2019. An ancient Harappan genome lacks ancestry from Steppe

Today, modern biological anthropology is concerned with much more.[21] Serious scholarship is now concerned with the reconstruction within an ancient society of biological profiles and human demography that includes and is understanding of, e.g., mortality, morbidity, health, disease, nutrition, fertility and fecundity, medicine, migration of people, and migration of disease.

There is also the need for caution, particularly when studying traumatic injuries for example. The Late Harappan Phase intramural skeletons from Mohenjo-daro have been in the past identified to be the victims of a massacre by a so-called Indo-Aryan invading army. Subsequent study has shown them to have been nothing of the sort and are likely victims of disease.[22] It cannot be assumed that a cranium found apart from its sub-cranial skeleton is evidence for massacre or decapitation, nor missing long bones a possible indication of amputation. Many bone lesions that may apparently be identified as physical trauma often have post-mortem and post-burial causes.

Before passing on to consider healing and medicine in the period, one of the things that characterises the study of human skeletal remains from the Indus Civilisation is not the disarticulation of the remains, itself problematic, but sometimes the disarticulation of the literature. In the past, some of those publishing the results of archaeological fieldwork from sites of the Indus Civilisation, particularly much earlier excavation reports, do not always contextualise their skeletal finds, often publishing information without primary references, grave numbers, and skeleton numbers. This makes work such as this more difficult if one is to identify certain graves and individuals buried therein and not to make mistakes in the identification of both the individual and the pathology described. Thankfully, a basic register of all human skeletal remains found in India has now been published and goes significantly towards understanding the extent of these remains and the possibility of further study, although it is recognised that those from the Indus Civilisation are still comparatively few.[23]

Ancient Healing and Medicine

As with the study of the history of disease, healing, and medicine for any period of the human past, the study of it within the Indus Civilisation, with its known limitations, leads to further caution. One is always conscious of the problem in medical history of applying modern concepts, ideas, and clinical definitions to describe earlier and sometimes more primitive societies. If one is not careful, this can result in a seriously distorted perception of that society. It is not possible to investigate the past through the lens of the present.

I should also warn readers, perhaps not too familiar with the study of ancient medicine, about one theoretical position that underpins much of what is understood from this and similar research.

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pastoralists or Iranian farmers. *Cell* 179: 729-735; Varghese Narasimhan *et al.* 2019. The formation of human populations in South and Central Asia. *Science* 365: On-line: east7487.

[21] The previous work in this field has been summarised by Kennedy from his work on the skeletons from Cemetery R37 at Harappa, see Kennedy, K. 2005. Biological Anthropology of Human Skeletons from Harappa, in *Retrospect*: 293-316. See also Kennedy, K. 2005. Archaeological and Anthropological Research in South Asia: developments of the past fifty years. *Man and Environment* 31(1): 36-41.

[22] Walimbe, S.R. 2011. Aryan invasion in the Indian Sub-Continent: facts and fallacies – the physical anthropology perspective. *Iranian Journal of Archaeological Studies* 1: 35-43.

[23] Mushi-Tripathy, V. *et al.* 2016. Where are they now? The Human Skeletal Remains from India, in G.R. Schug and S.R. Walimbe (eds) *A Companion to South Asia in the Past*: 496-533. Chichester: John Wiley.

The first tendency of many is to view the diagnoses and treatments in ancient medicine as weird and outlandish, clearly a product of ignorance and superstition, although with an occasional lucky discovery that worked. This evaluation is based upon the standards of our own western scientific medicine. When it resembles a little of what we recognise today in modern medicine or surgical procedures, then it is considered rational, perhaps even scientific, while those ideas and practices that do not fit this pattern are labelled superstition or sorcery and ignored. This leads to a misunderstanding of these societies. The selective singling out of modern medically acceptable elements misses seeing the total healing activities of a culture, including the aspects that we classify as religious or magical, as an interconnected health care system and makes it impossible to gain valuable insights into their culture and ideology.

There is also the nature of the society itself. Ancient societies often suffer from a stereotype. This is particularly acute for our perception of the Indus Civilisation, as popular convention often considers its population as coming from a peace-loving, egalitarian and prosperous society, made wealthy by trade and pastoralism, where attention is often superficially focused on the architecture of the large urban centres and differing aspects of their culture. Whilst this picture is accurate in so many ways, it neglects the unavoidable realities of everyday life for much of the population who lived in both the urban centres and in rural communities.

Sources

This book is both a synthesis of what is currently known about health, disease, and healing in the Indus Civilisation, combined with original research. It has been produced from a detailed study of published work on human skeletal remains and upon an understanding of their material culture and with an increasing awareness of the natural environment. When combined with a knowledge of palaeoepidemiology and the natural history of disease, ancient climate change and its effect on disease patterns and what is known of healing, medicine, and health in contemporary Bronze Age societies of the Near East, with which the Indus Civilisation was in contact, it has been possible to piece together a knowledge of disease, the practice of healing and the development of public health. This has therefore led to an understanding how the Indus Civilisation was affected by disease, how long they lived, and from what they died.

Of all the contemporary ancient societies, the Indus Civilisation is unusual in the degree by which we are wholly reliant on archaeology for an understanding of its culture. Several ancient societies, such as those of the Near East and Egypt, have a comparatively rich textual record of healing and medicine. However, the Indus Script currently remains undeciphered and this means that it does not offer us the same resources. One can only hope that if the decipherment is eventually achieved, it will perhaps offer a glimpse of something of Indus Civilisation healing practices. However, the very nature of the script suggests this is unlikely.

This Book

This book brings together for the first time a comprehensive picture of the health, diseases and healing of the population of the Indus Civilisation and offers an important contribution to its social prehistory. For those archaeologists and medical historians unfamiliar with the civilisation, Chapter One offers a background to the civilisation, its origins and decline, but primarily its Mature Harrapan or Urban Phase (2600-1900 BC) and its chronology. Chapter Two

examines the health of the population, life expectancy, nutrition and urbanisation and the overall effects of disease, singling out women and children. This theme continues in Chapter Three, which examines in detail individual diseases and trauma, including dental disease. Chapter Four looks at occupational health, detailing the diseases, injuries and hazards faced by metalworkers, craftsmen, farmers, textile workers, sewer cleaners, builders, carpenters, bricklayers, and many others. Chapter Five describes the major public health, sanitation and water supply infrastructure that exists in the major cities, especially Mohenjo-daro. The subject of how the populations of the Indus Civilisation were healed from the effects of disease and trauma, whether by themselves, others, or their gods, detailing the evidence we have for their *materia medica*, is discussed in Chapter Six. Chapter Seven is a short epilogue, bringing together various strands of the main argument of the work. For the first time, this book illustrates the health, life expectancy, and the illnesses and injuries from which those at the bottom of society suffered, both at work and at home.

Finally

I first became interested in the Indus Civilisation when I read at school the works of Stuart Piggott, Sir Mortimer Wheeler, and Raymond and Bridget Allchin. This interest was renewed during my first visit to India in 2007, when I became involved with Bilga General Hospital, a charitable institution in the Indian State of the Punjab, serving the poor amongst the villages that exist along part of the western shore of the Sutlej River, near Jalandhar, and I was able to visit India very frequently and take some time off to pursue research. It is particularly gratifying to contribute to the early history of healing in a region of India where I work in modern global health and rural healthcare. The change after having studied disease and medicine in the prehistoric Aegean and Anatolia for thirty-five years has been refreshing. However, it is also gratifying to know that I learned much of my archaeology in the same research institution as Sir John Marshall, namely at the British School at Athens, and excavating on Crete, being like him, firstly a Minoan and then an Harappan.

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Abbreviations

aDNA	Ancient DNA (Deoxyribonucleic acid).
Ancient Cities	Kenoyer, J.M. 1998. *Ancient Cities of the Indus Valley Civilisation*. Karachi: Oxford University Press/American Institute of Pakistan Studies.
Ancient Indus	Wright, R.P. 2010. *The Ancient Indus: urbanism, economy and society*. Cambridge: Cambridge University Press.
Bioarchaeology	Lovell, N.C. 2016. Bioarchaeology of the Indus Valley Civilization: biological affinities, paleopathology and chemical analysis, in G.R. Schug and S.R. Walimbe (eds) *A Companion to South Asia in the Past*: 169-186. Chichester: Wiley Blackwell.
Biocultural Context	Lovell, N.C. 1998. The Biocultural Context of Anemia in the Ancient Indus Valley. *Journal of Human Ecology* 9: 205-219.
Burial Practices	Halim, M.A. 1991. Burial Practices at Harappa, in M. Jansen, M. Mulloy and G. Urban (eds) *Forgotten Cities on the Indus: early civilisation in Pakistan from the 8th to the 2nd millennium BC*: 198-206. Mainz: Verlag Philipp von Zabern.
Cemetery R-37	Lovell, N.C. 2014b. *Skeletal paleopathology of human remains from Cemetery R-37 at Harappa*. Edmonton: University of Alberta Education and Research Archive (ERA) (http://hdl.handle.net/10402/era.39921).
Chanhu-daro	Mackay, E.J.H. 1943. *Chanhu-daro Excavations, 1935-1936*. American Oriental Series 20. New Haven: Harvard University Press/American Oriental Society/American Society of Indic and Iranian Studies/ Museum of Fine Arts, Boston.
Contemporary Perspective	Possehl, G.L. 2002. *The Indus Civilisation: a contemporary perspective*. Lanham: Altamira Press.
Departed Harappans	Sharma, A.K. 1999. *The Departed Harappans of Kalibangan*. New Delhi: Sundeep Prakashan.
Disease[3]	Roberts, C. and K. Manchester 2005. *The Archaeology of Disease* (3rd edition). Ithaca: Cornell University Press.
Diseases in Antiquity	Brothwell, D. and A.T. Sandison (eds) 1967. *Diseases in Antiquity. A survey of the diseases, injuries and surgery of early populations*. Springfield: Charles C. Thomas.
Emergence	Wenke, R.J. and D.I. Olszewski 2006. The Evolution of Complex Societies in the Indus Valley, in *Patterns in Prehistory: humankind's first three million years*: 405-431. Oxford: Oxford University Press.
Forgotten Cities	Jansen, M., M. Mulloy and G. Urban (eds) 1991 *Forgotten Cities on the Indus: early civilisation in Pakistan from the 8th to the 2nd millennium BC*. Mainz: Verlag Philipp von Zabern.
Further Excavations	Mackay, E.J.H. 1938. *Further Excavations at Mohenjo-daro: being an official account of archaeological excavations at Mohenjo-daro carried out by the Government of India between the years 1927 and 193*. Delhi: Government of India and Archaeological Survey of India.

Harappa	Vats, M.S. 1940. *Excavations at Harappa: being an account of archaeological excavations at Harappa carried out between the years 1920-21 and 1933-34*. Delhi: Government of India and Archaeological Survey of India.
Healing Hand	Majno, G. 1975. *The Healing Hand: man and wound in the ancient world*. Cambridge: Harvard University Press.
Human Paleopathology	Aufderheide, A.C. and C. Rodriquez-Martin 1998. *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge: Cambridge University Press.
Indus Civilisation	Wheeler, M. 1968. *The Indus Civilisation* (3rd edition, supplementary volume to the *Cambridge History of India*). Cambridge: Cambridge University Press.
Indus Ethnobiology	Weber, S.A. and W.R. Belcher (eds) 2003. *Indus Ethnobiology. New Perspectives from the Field*. Lanham: Lexington Books.
Infection	Schug, G.R., K.E. Blevins, B. Cox, K. Gray and V. Mushrif-Tripathy 2013. Infection, disease and biosocial processes at the end of the Indus Civilization. *PloS ONE* 8: e84814.
Lothal	Rao, S.R. 1973. *Lothal and the Indus Civilisation*. Bombay: Asia Publishing House.
Malaria	Knell, A.J. (ed.) 1991. *Malaria*. Oxford: Oxford University Press/The Wellcome Trust.
Mohenjo-daro	Marshall, J. (ed.) 1931. *Mohenjo-daro and the Indus Civilisation, being an official account of the archaeological excavations at Mohenjo-daro carried out by the Government of India between the years 1922 and 1927* (3 volumes). London: Arthur Probsthain.
MTBC	*Microbacterium tuberculosis* complex.
Pathological Conditions	Ortner, D. 1981. *Identification of Pathological Conditions in Human Skeletal Remains* (2nd edition). San Diego: Academic Press. *umHumH*
Peaceful Realm?	Schug, G.R., K. Gray, V. Mushrif-Tripathy and A.R. Sankhyan 2012. A peaceful realm? Trauma and social differentiation at Harappa. *International Journal of Paleopathology* 2: 136-147.
Plagues	McNeill, W.H. 1977. *Plagues and Peoples*. Oxford: Basil Blackwell.
Pre-Roman Diseases	Ortner, D.J. and G. Theobald 1993. Diseases in the pre-Roman world, in K.F. Kiple (ed.) *The Cambridge World History of Human Disease*: 247-261. Cambridge: Cambridge University Press.
Retrospect	Korisettar, S. and R. Korisettar (eds) 2002. *Indian Archaeology in Retrospect*, Volume II, *Protohistory: Archaeology of the Harappan Civilization*. New Delhi: Manohar/Indian Council of Historical Research.
Rise of Civilisation	Allchin R. and B. Allchin 1982. *The Rise of Civilisation in India and Pakistan*. Cambridge: Cambridge University Press.
South Asia	Agrawal, D.P. and J.S. Kharakwal 2003. *Bronze and Iron Ages in South Asia*. Archaeology of South Asia II. New Delhi: Aryan Books International.
Trading Encounters	Ratnagar, S. 2004. *Trading Encounters: from the Euphrates to the Indus in the Bronze Age*. Delhi, Oxford University Press (revised edition of *Encounters: the westerly trade of the Harappan Civilisation* (1981). Delhi: Oxford University Press.

Tradition Kenoyer, J.M. 1991. The Indus Valley tradition of Pakistan and Western India. *Journal of World Prehistory* 5: 331-385.

Transformation Possehl, G.L. 1997. The Transformation of the Indus Civilisation. *Journal of World Prehistory* 11: 425-471.

Trauma and Disease Kennedy, K.A.R. 1984. Trauma and disease in the ancient Harappans: recent reassessments of the skeletal record, in B.B. Lal and S.P. Gupta (eds) *Frontiers of the Indus Civilization*: 425-436. Sir Mortimer Wheeler Commemorative Volume. New Delhi: Books and Books/Indian Archaeological Society and Indian History and Culture Society.

Tuberculosis Roberts, C.A. and J.E. Buikstra 2003. *The Bioarchaeology of Tuberculosis: a global view on a re-emerging disease*. Gainesville: University Press of Florida.

Walimbe Walimbe, S 2022. Protohistoric human skeletal evidence in India: research status and prospects. *Journal of the Indian Anthropological Society* 57: 103-122.

Water and Sewage Jansen, M. 1989. Water supply and sewage disposal at Mohenjo-daro. *World Archaeology* 21: 177-192.

Chapter One

The Indus Civilisation

This book is concerned with the Indus Civilisation's health, from what diseases the populations suffered and died, and their healing and medical practices. But first, for those readers perhaps unfamiliar with the civilisation in any great depth, this chapter offers a short introduction.

During the 3rd millennium BC, the northwest of the Indian sub-continent witnessed the rise of a major, complex urban civilisation, that of the Indus. It was a Bronze Age society, located in modern terms on a region which covered an area that extended from, in the west, Sutkagendor on the Makran coast in modern Pakistan near the Iranian border, to Alamgirpur, near Delhi in the east, and in the north at Shortughai in North West Afghanistan, by the border with Tajikistan, and to the south with evidence of Indus Civilisation influence at Daimabad, north-east of Mumbai. The area included the vast majority of modern Pakistan and the present Indian states of Gujarat, the Punjab, Haryana, and much of Rajasthan and Uttar Pradesh, i.e. just over 1,500,000 km^2, much larger than its contemporary Mesopotamian and Old Kingdom Egyptian civilisations. Up to 1500 sites, large and small, have been discovered from all phases, the majority from the Mature Harappan or Urban phases.[1]

The term urban society, whilst reflecting a major social and economic shift from a Pre- and Early Harappan phase rural economy, and an economy dominated by urban centres, the culture was not an exclusively urban one, as its economy had a sound agricultural base, with much of its population still living in rural agricultural communities.[2]

The appearance of the Mature Harappan phase of the Indus Civilisation, *c.* 2600 BC, was originally thought to be the result of cultural diffusion or even acculturation from the Near East. This notion has now been completely discredited by the discovery of a structured subsistence economy and proto-urbanisation stretching back to the Early Harappan in 3300-2600 BC. This developed directly from the Aceramic Neolithic that began in the 7th millennium BC, in such centres as Mehrgarh, located on the border of south Baluchistan and Sind, now in modern Pakistan, and shows a slow development of their society and cultures. At the same time, we also have a much clearer picture of the decline and end of the Indus Civilisation and their gradual replacement in the 2nd millennium BC, by other cultures.[3]

Significantly, excavations at Mehrgarh, a Neolithic site located on the Kacchi Plain of Baluchistan, now in modern Pakistan (see section on the Pre-Harappan below), have uncovered a settlement whose eight periods of occupation, span some 5000 years, thus providing a chronological backbone for our understanding of the indigenous development of

[1] Possehl 1999: 727-835 (for full gazetteer of sites to 1999). For an overview of rural and urban settlement see *Tradition*: 349-353. For a more recent gazetteer of sites in the Gujarat and the Greater Indus Valley, see Meena *et al.* 2009: 83-167 (Appendices 1 and 2).

[2] Cf. Meadow in *Forgotten Cities*: 51-65; Meadow 1996: 390-412.

[3] For a view on the historiography of the archaeology of the Indus Civilisation and what the authors call the dichotomy between traditional Eurocentric models of social organisation and those derived from the cultural traditions of South Asia, see Coningham and Manuel 2009: 167-180.

the Indus Civilisation, from the Neolithic and the Pre- and Early through to the Late or Post-Urban Harappan phases.

The term Indus Civilisation is now accepted by many scholars,[4] considering the rapidly growing discovery of sites particularly to the east and south of the valley of the River Indus and in the valley of what is now called the Ghaggar-Hakra River. However, the use of the alternate term the Harappan Civilisation, tends to give undue prominence to one of the major sites, particularly as we are unaware of the relationship between them. The civilisation is also sometimes referred to as the Indus Ghaggar-Hakra Civilisation or even the Indus-Saravati Civilisation, as the ancient landscape included what is now a dry riverine system in the Punjab,[5] but the term 'Indus Civilisation' is preferred, the name given to it by Sir John Marshall and the first excavators.

The earliest excavations of the cities of the Indus Civilisation were at Harappa and then Mohenjo-daro and these remain to date the most important urban complexes.[6] What they were not, were the two centres or twin capitals of an Indus Empire. Other important urban centres include Ganweriwala, Dholavira, and Rakhigarhi, although Ganweriwala still awaits extensive excavation. It is important to define the Indus Civilisation, during its Mature Harappan phase, with sites having finds that include, at least, certain kinds of pottery, miniature clay animals, cubic chert weights with precise weight-values, long and thin blades of the same chert used as tools, rectangular stamp seals, inscribed seals with animal emblems and perforated bosses, metallurgy with open-cast tools, bronze alloys, lost-wax casting, soldering and gold granulation, and the use of the Indus Script.

It is possible to argue that Mohenjo-daro was special. The occurrence of stone statuary of both men and animals almost exclusively at the site is possible evidence of its special importance, and the use of fired bricks in its construction is also a pointer to a huge scale of labour mobilisation in its building industry. Of the cities of the Indus Civilisation, the size, density, town planning and advanced public health infrastructure of Mohenjo-daro, established it as likely to be the major centre. It was deliberately planned and there is no evidence for occupation before the Mature Harappan. Mohenjo-daro was an important centre for trade networking with the Near East.

The location and density of Harappa shows that the settlement was the major urban centre of the upper reaches of the River Beas, a tributary of the River Indus. In *c.* 2450 BC, economic activities developed, such as craft technology, bead making, and seal production. Some of these craft activities, involving agate, lapis lazuli, blue-glazed faience, drilled carnelian and serpentine, suggest that the settlement was also involved in long-distance trade with the Near East through Gujarat, resourcing commodities from Afghanistan.

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[4] G. Possehl, 'What's in a Name? The "Indus Civilization" onomastics and the rules of science', unpublished manuscript, personal communication, 25 August 2009. His argument to use the term Indus Civilisation is convincing.

[5] For a brief introduction to the physical geography of the Indus region, see *Indus Ethnobiology*: 4-9.

[6] The existence of the Indus Civilisation was first announced in 1924 by the then Director-General of Archaeology in India under the British Raj, Sir John Marshall (*Illustrated London News*, 20 September 1924: 528-534, 548). For his first formal report see Marshall 1924: 47-51. Harappa was excavated by Pandit Daya Ram Sahni (1920-1921, 1923-25) and Madhu Sarup Vats (1926-1934), see *Harappa*. Mohenjo-daro was first excavated by Professor Rakhal Das Banerjee (1922-1923), R.B. Kashinath Narayana Dikshit (1924-1925), Marshall personally (1925-1926), and then Ernest Mackay (1927-1931), see *Mohenjo-daro* and *Further Excavations*.

Ganweriwala has been subjected to a surface survey, which indicates that its location, size, and characteristics emphasise its importance. The size and location site of Dholavira reflects its importance as an urban centre, specialising in trade. Its earliest period of occupation was around 2600 BC, like Mohenjo-daro. Knowledge of Rakhigarhi is limited, but based on what we know, it was the regional urban centre of the Ghaggar River region and that Ganweriwala was a major urban centre for the control of trade in the Ghaggar-Hakra system. Other major sites include Chanhu-daro in Sind, Lothal and Surkotada in Gujarat, Kalibangan in Rajasthan, Ropar in the Punjab, and Bhirrana in Haryana. Smaller settlements, mostly of the Mature Harappan, are to be found as far afield as the coastal sites that extended from western Baluchistan to Gujarat. An Indus settlement, Shortughai, has also been found on the River Oxus (Amu Darya) in the far north-east of Afghanistan, by the border with Tajikistan, controlling the local source of the trade in lapis lazuli, tin and gold. There is also an Indus Civilisation site at Manda on the Beas River near Jammu and another at Alamgirpur, on the Hindon River, only 28km from New Delhi.

Many Indus Civilisation sites have been discovered along the dry riverbeds of the Ghaggar-Hakra River and its tributaries, in contrast to only about 100 along the River Indus. What is of significance is the consistency in culture and the huge area it sustained, particularly in the Mature Harappan. These cities, towns and villages were not isolated city-states, nor were they part of a centralised state, but formed a loosely integrated and interconnected regional mosaic of urban and rural culture, where we see the concurrence of two important factors which brought the civilisation to its maturity, namely the pre-eminence in the region of many incipient urban trading communities, the stimulus of contacts with other societies outside, including Central Asia, the Gulf and Mesopotamia, and the rich natural environment offered by the rivers on whose banks it flourished.

There is unmistakable evidence of maritime trade between the Indus Civilisation and Mesopotamia from the time of King Sargon of Akkad, who lived in the 24th century BC, and the Ur III and the Isin-Larsa dynasties. This evidence mainly consists of seals with the undeciphered Indus Script found in Mesopotamia and the Gulf, and of a seal used in the trade and cultural exchange of commodities that originated in the Gulf that was found at Lothal in Gujarat. At the same time, cuneiform texts found in Mesopotamia, detail sea trade with locations such as *Dilmun*, believed to be located at Bahrain in the Gulf, *Makkan*, perhaps in Oman on the Makran coast, and *Meluḫḫa* now identified with the Indus Civilisation. Its population must be seen as an integral part of a wider social development. As Possehl reminds us, it 'represents the easternmost manifestation of an interregional pattern of third millennium urbanisation that encompasses the Nile valley and the lands from the Mediterranean Sea, east across the Iranian Plateau to the Greater Indus Region.'[7]

Chronology

The chronology of the Indus Civilisation (Table 1) is based on the use of the traditional three major phases, i.e. the Early, Mature, and Late Harappan, although we include also the term Pre-Harappan. It largely supports, in terms of dates and technological and social development, Possehl's chronology, which is based on a series of stages.[8] Preference has been given to the

[7] *Contemporary Perspective*: 247; Ratnagar 2001: 351-379.
[8] *Contemporary Perspective*: 29. A full discussion of the chronology and differences between scholars can be found in

Table 1. Chronology of the Indus Civilisation to 1700 BC.

DATE (BC)	PHASE	SITES AND EVENTS
	Pre-Harappan Phase [Early Food Producing Era]	
7000 6000	Aceramic Neolithic	Mehrgarh IA First Farming Community at Mehrgarh Beginnings of village farming communities and pastoral camps
6000 5500	Aceramic and Ceramic Neolithic	Mehrgarh IB Start of pottery making at Mehrgarh
5500 4300	Neolithic	Mehrgarh IIA-B Start of copper smelting
4300 3300	Chalcolithic	Mehrgarh III-IV Developed village farming communities and pastoral societies Use of potter's wheel Copper casting
	Early Harappan Phase Pre-Urban [Regionalsation Era]	
3300 2800	**Harappa 1A/B** Ravi Phase3	Foundation of Harappa First use of bronze
2800 2600	**Harappa 2** Kot Diji Phase	Harappa Kalibangan I Dholavira and Rakhigarhi founded Early script at Harappa Craft specialisation
2600 2450	Transition Period **Harappa 3A** (2600-2450 BC)	Some settlements destroyed and abandoned New Settlements established Mohenjo-daro founded Expansion of craft specialisation Emergence of writing
	Mature Harappan Phase Urban [Integration Era]	
2450 1900	Urban Phase **Harappa 3B** (2450-2200 BC) **Harappa 3C** (2200-1900 BC)	Harappa Mohenjo-daro Mehgarh VIII Lothal (Period A) Kalibangan II Cultural unity in Indus region Internal distribution network External overseas trade expanded Towns and cities and industrial villages
1900 1800	Late Mature/Transitional Phase **Harappa 4**	Lothal (Period B, Phase V) Decline of many towns and cities Flow of River Ghaggar-Hakra reducing Transition to Post-Urban phase
	Late Harappan Phase Post-Urban [Localisation Era]	
1800 1700	Post-Urban Phase **Harappa 5** Harappa Cemetery H Late Harappan in Gujarat	Destruction levels at Harappa and Mohenjo-daro Disintegration of Harappan polity Ending of overseas trade Development of strong regional centres in Gujarat and the Punjab

use of the looser term 'phase' rather than the more exact 'period', as found in the Near East and Eastern Mediterranean at this time. This use is also determined by the existence of less structured cultural relationships that existed over such a massive area.

Additionally, there is also the use of the term 'era', which can be correlated with the phases: (a) Early Food Producing era, in which the economy is based on food production and the absence of ceramics (Pre-Harappan); (b) Regionalisation era, which is characterised by distinctive artefact styles (mainly ceramics) that are clustered in geographical extent and time, with interaction networks linking dispersed social groups (Early Harappan); (c) Integration Era in which the material culture displays homogeneity over a large area, indicating an intense level of interaction (Mature Harappan); and (d) Localisation era is comparable to the Regionalisation era, except that there is more generalised similarity in artefact styles. This indicates that the interaction networks maintain a continued but altered presence (Late Harappan).

The chronology and hence the use of 'Harappan' is best exemplified by the stratigraphy at the major urban centre of Harappa, where five major periods of settlement between 3300 and 1700 BC have been determined using architectural phases, the analysis of diagnostic artefacts, and 70 radiocarbon dates from primary context hearths or floors.[9] The first settlers at the site formed a small agricultural community near the River Ravi *c.* 3300 BC (Harappa 1A-B). The location of the settlement was originally ideal for farming, as well as access for hunting, gathering, and fishing. This earliest settlement is characterised by small houses made from mudbrick and the beginnings of craft specialisation, such as the manufacture of pottery and body ornamentation made from semi-precious stones and marine shell. Subsequently, as the settlement became larger and more sophisticated, it gained in importance as a crossroads for trade between the highlands to the west and north and the vast alluvial plains to the east and south. By 2800 BC (Harappa 2), the village was transformed into a proto-urban centre that covered more than 25 ha. Within a timeframe of only 200 years, by 2600 BC it had developed into one of the major centres of the Indus Civilisation. During the latter period of the Mature or Urban phases, 2450-1900 BC (Harappa 3B-C), the city extended to well over 150 ha.[10] Unfortunately, there is no internal chronology for the Mature Harappan. Except for a very few objects, we cannot separate out the earlier-period material, from *c.* 2600 BC, from material of a period closer to 1900 BC.

Pre-Harappan Phase

The Indus Civilisation came into being as the result of a long, cultural evolution and indigenous development at the intersection of the Indo-Iranian plateau and the Indus plain, over literally thousands of years, based on the long-term cultural interaction of people beyond the river plain itself. For the Pre-Harappan there is evidence from the Kochi Plain that the Neolithic period in and around the Indus valley can be dated to as early as the beginning of the 7th millennium BC, and appears to be evidence of the earliest farmers of South Asia.[11] The Kochi Plain,

Tradition: 334-339. For a modified chronology, see Manuel 2010: 145-152.

[9] *South Asia*: 68-76.

[10] Kenoyer 1997: 266. For Harappa, see Kenoyer 1991b: 29-59. For carbon dates, see *Tradition*: 337-338 (Table III), and for the listing of radiocarbon dates from all sites, see Lal 1997: 239-254.

[11] *Contemporary Perspective*: 23-49; Fuller *et al.* 2001: 171-187. See also Lemmen and Khan 2012: 107-114 for a discussion on the likelihood of an earlier common South Asian Neolithic. Within India, several sites have been identified along the now dried-up Ghaggar-Hakra, e.g. Jalipur, Bhirrana and Kunal, that also record, like Mehrgarh, a period of continuity

which strides the interface of Baluchistan and the Indus valley, offers a number of important resources, such as nearby highlands for the summer grazing by transhumant pastoralists, whereas the plain itself provided natural plant resources and land for the cultivation of cereal crops, such as the wild progenitors of wheat, barley and for the domestication of cattle, sheep and goats. The rivers provided flint nodules for the manufacture of tools and cooking utensils and we also see the first weapons made from animal bone.

This gradual growth of both pastoral and arable agriculture and the expansion in population size is particularly reflected in the finds at the early farming community of Mehrgarh (Mehrgarh I) in Baluchistan. Here we see the start of the cultivation of wheat and barley, particularly the introduction of six-row barley and the herding of cattle, sheep and goats, which supplemented and eventually superseded hunting. In the villages, we also see the growth of houses made from mudbrick and the manufacture of flint and chert blades, microliths, polished axes and grinding stones. Lapis lazuli, turquoise and marine shells were brought in from Iran and what is now Afghanistan to meet the demand for very early luxury goods.

Later we witness the start of village communities that would eventually become urbanised, part of a gradual change from Neolithic modes of production to an early complex society (Mehrgarh II). The finds from the burials located in the open areas in this period included a rich variety of bone, shell, and stone objects. Some infants were buried with rich grave goods, perhaps suggesting the inheritance of an elite status. By this time, the 6th millennium BC, handmade pottery had been introduced and storehouses built in the village, used for the storage and redistribution of food and also for the storage of the valuable raw materials of an emerging craft specialisation and manufactured goods used for trade, demonstrating a fairly high level of social organisation.[12]

At Mehrgarh 1000 years later (Mehrgarh III-IV),[13] we also witness technological change and find the first use of metals and a continual growth in the size of the settlement, which now covered an area of 750 ha; with a length of 1.5 km along the bank of River Bolan. The metal first used was copper, although the predominant materials for tools firmly remained flint and chert. Bronze technology did not develop fully until the settlements moved to the alluvial plain in the Early Harappan. Villages throughout the region grew to dozens of hectares. Settlements also spread eastwards beyond the Indus to Cholistan in the delta of what some believe to be the Ghaggar-Hakra River, again following the trails of transhumant farmers. Similarity in pottery forms with what is modern southern Turkmenistan and northern Iran also suggests some mobility and trade. The potter's wheel was known from *c.* 4500 BC.

The sophisticated societies that were developing on the Kochi Plain must have formed the basis for the eventual expansion into the Indus valley, which consequently gave birth to the Indus Civilisation; the more austere environment of the alluvial plains of the Indus valley

from the 7th millennium BC to the Mature Harappan phase. This supports the contention that it developed directly from the Aceramic Neolithic in the 7th millennium BC and shows a slow and completely indigenous development of their society and cultures (Dikshit and Mani 2013: 47-59.

[12] *Forgotten Cities*: 51-65; Jarrige *et al.* 1995.

[13] *Forgotten Cities*: 66-72.

could now only be colonised after the development of an earlier complex society with its new technology.

Also of significance are the various other Late Neolithic and Chalcolithic societies in the vicinity of the Indus valley, found spread over a wide geographical area, which, for whatever reason, developed at differential paces over millennia, even if some maintained strong contacts with the Indus Civilisation. For example, the Ahar-Banas people, a Chalcolithic society located in the valley of the River Banas in south-east Rajasthan, formed *c.* 3000 BC and was at its height in 2100-1500 BC; it flourished as its own pace, but for some reason did not develop into an urbanised society.[14]

Returning to Mehrgarh and its importance for our understanding of the sequence of prehistory in the region, the excavations undertaken between 1974 and 1985 provided the earliest evidence for sedentary life going back to the 7th millennium BC, but it has also given us solid evidence for the steady and gradual emergence of all the elements that made up the Indus Civilisation. The excavations have demonstrated seven different stages of development prior to the emergence of the Mature Harappan phase in the last stage (Mehrgarh VIII) and show the introduction of various elements of the Indus Civilisation at different levels at the site throughout all seven periods of occupation across the Early, Mature, and Late Harappan phases and demonstrate the cultural process, from origin through development to decline, although the settlement ceased to be of any major importance at this time. The Mature Harappan is the most prosperous and shows the development of the civilisation into an urbanised society. This is now supported by evidence from other excavated sites and leads us to clearly understand that the Mature Harappan emerged locally out of what went earlier; a process of transformation that appears to have happened simultaneously over the whole region. What was uncovered at Mehrgarh laid to rest once and for all the earlier theory that those cultures further to the west, in the Near East and what is now Iran, were largely responsible, through diffusion, for the emergence of the Indus Civilisation.

Early Harappan (or Pre-Urban) Phase

The Early Harappan lasted from *c.* 3300 BC until 2600 BC and its first appearance was Harappa 1, during the time of the production of Ravi/Hakra Ware pottery, named after the site of the nearby River Ravi and the Ghaggar-Hakra River valley to the west. During the Early Harappan, many new settlements, mostly farming, come into existence, which was to be a challenging environment because of the annual floods, but which rewarded its occupants with fertile land for arable farming. As a consequence, the site of Mehrgarh was now largely depopulated, with the inhabitants moving away to the nearby site of Naushero, 9 km away, although it was never fully abandoned.

The use of potters' marks points to possible socio-economic structures within the phase, and stamp seals bearing geometrical motifs suggest developments in administration; we also see advances made in most crafts. Similarities in pottery, seals, figurines and other objects, document intensive caravan trade with Central Asia and the Iranian plateau.[15]

[14] *Rise of Civilisation*: 262-264. However, it is now thought that here was an element of complexity about the Ahar-Banas People, as it now shows surprising evidence for the use of seal impressions.

[15] For overview of the Early Harappan, see *Rise of Civilisation*: 131-165; Mughal 1990: 175-199; *Forgotten Cities*: 104-110;

Sufficient Pre-Harappan and the later Early Harappan settlements have been located and excavated to identify a local progression from hunter-gatherers to urban dweller, by way of the stages of pastoralism, agricultural settlement, technological advance and cultural refinement. Designated by their sites and distinctive pottery styles, towards the end of the Pre-Harappan, these settlements had progressed to building mudbrick houses on orderly rectangular street plans, cultivating land, developing metallurgy, and trading for mineral and other resources. Not strictly planned, these settlements had a wide street running north–south, with narrower secondary streets, perpendicular and parallel to it. Some of the early towns had a large rectangular raised area or citadel, often with some residences on the top and the sides held up by retaining walls, although this has often been misinterpreted as defensive. Whether any of the dwellings were elite cannot be determined from the finds. This was simply the safest area when the floods came. Some early towns were fully walled, probably also for flood prevention.

Later on, the Kot Diji phase (Harappa 2), dating from *c.* 2800-2600 BC, so named after the site in northern Sind, near Mohenjo-daro, represented also by the sites of Rehman Dheri and Amri, announces the start of the transitional phase leading up to Mature Harappan, with an increasingly urban quality of life and witnessing the development of craft specialisation. Another rapidly expanding urban settlement of this phase is found at Kalibangan (Kalibangan I),[16] located on the Hakra River in Rajasthan. Trade networks linked this culture with related regional cultures and distant sources of raw materials, including lapis lazuli and other materials for bead-making. The occupants had by this time, domesticated numerous additional crops, including peas, sesame, dates, and cotton, as well as additional animals – including the ubiquitous zebu.

Up to the Kot Diji phase, the culture of the early towns was independent, self-sufficient, and local; they differed from place to place, each with a distinctive style of pottery. Many towns practised craft specialisation, some made axes and grinding tools for cereal processing, thought to be for exchange with other communities. During this phase, however, there seems to have developed some uniformity, certainly in pottery styles, heralding later developments. One of the most important discoveries of the Kot Diji phase levels was primitive writing, the forerunner of the Indus Script, which had emerged by 2800 BC.

Mature (or Urban) Harappan Phase

After 2600 BC, we now see the beginning of the transition of the Early Harappan agricultural communities into much larger urban centres and more complex societies. They include those at Harappa, Mohenjo-daro, Ganweriwala, Dholavira, Kalibangan, Rakhigarhi, Ropar, and Lothal. Many settlements of the period, large and small, have also been located.

A relatively short, but less well understood transitional phase, dated between 2600-2450 BC (Harappa 3A), transformed the Early Harappan into the Mature Harappan,[17] when the developed Indus Script was first used. The size of the fired brick, already in use during the Early Harappan period, was standardised and made with measurements in the perfect decimal ratio of 4:2:1, highly effective for bonding. Mudbrick built houses, still in the majority, were

Contemporary Perspective: 40-53.
[16] Thapar 1973: 85-104; Lal *et al.* 2003.
[17] First defined in Casal 1964: 39-43.

now built in a regular design with a courtyard and rooms off it. Weights of carefully cut and polished chert cubes now form a combined binary and decimal system. The society began to become so highly organised and complex that it could complete enormous projects, i.e. the building of the features of a major urban centre.

All of this is best epitomised at Harappa itself. Already a walled city of 25 ha by the Kot Diji phase, it produced quantities of jasper, agate, carnelian, and other stones, as well as importing steatite and carved stamps seals made of this same imported material. Pottery was made on the foot-powered potter's wheel, allowing for greater production, presumably for trade and exchange. Copper work became more common, but still comparatively rare. As for craft specialisation, the spread of Kot Diji pottery suggests interaction, possibly trade by oxcart, indicating larger-scale haulage of produced goods. Many of the seals and sealings with geometric motifs points to internal trade. Externally, stones were imported from Baluchistan and Afghanistan. Civilisation was emerging.

After the transitional phase, that lasted from *c.* 2600-2450 BC – although this short phase is usually included within the Mature Harappan – the full Mature Harappan phase (Table 2) has been dated from 2450-1900 BC, and is divided at Harappa into two sub-phases (Harappa 3 B-C), each reflecting a very distinct period of cultural development. The phase is best characterised by the emergence of distinct and large-scale complex features and the civilisation supported by sites, ranging from village farming communities and small towns to several fully developed and wealthy major urban centres or cities, such as Harappa, Mohenjo-daro, Rakhigarhi, Ganweriwala, and Dholavira, with populations that ran into tens of thousands. Many of the houses and other structures continued to be built from fired bricks and there is evidence of the existence of warehouses, massive walls, public health infrastructure, sophisticated water management, gateways, and extensive areas for craft and industrial production. This was supported by a rural subsistence economy consisting mainly of large-scale food production and pastoral farming.

The economy was largely based on agriculture, animal husbandry and on trade with specialised exchange networks for the sourcing and distribution of commodities and manufactured goods within and beyond the Indus Civilisation. It also likely evolved from its predecessors, using irrigated agriculture with sufficient skill to reap the advantages of the spacious and fertile Indus river basin, whilst controlling the formidable annual flood that simultaneously fertilises and destroys.

The Mature Harappan witnessed a period of rapid expansion, with a dense and heterogeneous and probably multi-lingual population. The larger cities now become economic centres that could offer opportunities unavailable in the hinterlands. Technology, production, and consumption had transformed society, where population growth and immigration disrupted the structured settlement pattern. Houses in the core areas of Harappa now spilled over onto the streets and suburban areas sprang up on low mounds to the west and northwest of its centre. We also witness an overall increase in population size, rising to *c.* 5,000,000.

Table 2. Characteristics of the Mature Harappan Phase (after Smith, M.L. 2006: 97-142).

CHARACTERISTICS OF THE MATURE HARAPPAN PHASE	
Time Period	2600-1900 BC
Data set type	Archaeological, undeciphered script (Indus Script)
Data set size	At least five major sites in the 60-150 ha range; broad excavations at Mohenjo-daro and deep excavations at Harappa; regional surveys with limited excavation of hinterland sites
Largest sites	Dholavira, Ganweriwala, Harappa, Mohenjo-daro, Rakhigarhi
Urban characteristics	Gridded street pattern, walled precincts within sites, large-scale public architecture of a practical nature (including baths and sewers)
Subsistence base	Cereals and pulses (wheat, barley, millets); animal husbandry (cattle, sheep, goats, water buffalo)
Reach of long-distance exchange	Contact with Mesopotamia and the Gulf
Social characteristics	Strong cultural links as indicated by uniform material culture and iconography and a shared script
Political characteristics	Egalitarian, probably not a unified regional system as traditionally understood using the word 'state'

[After Smith, M.L. 2006: 97-142]

Elites and State Formation

In ancient societies, elites may be archaeologically identified in several ways, such as: (a) an apparent control of the economic resources of that society; (b) elite residences; (c) the accumulation of wealth and its depiction in iconography; (d) the patronage of religion; (e) the patronage of craft industries; and (f) investment in elaborate burials with wealthy grave goods. Is it possible to identify Indus Civilisation elites? It has generally been believed that, on this basis, at no stage of the course of the civilisation, particularly in its Mature Harappan phase, was it possible to identify any elite residence, and neither is it possible to identify elite groups from the study of burial customs. The absence of seals, prestige objects and hordes of any description on the citadel mounds undermines the idea of their use for wealth accumulation or distribution. The presence of what appears to be uniformity, egalitarianism and the absence of an identifiable elite, and the absence of any evidence of slavery, has allowed various theories to account for its socio-economic structure. These have ranged from the existence of a so-called Indus Empire, with its capital at Mohenjo-daro, to a theocratic classless society, headed by Priest-Kings.

The absence of palaces and temples, however, makes the Indus Civilisation strikingly different from its contemporary counterparts in the Near East; but we do witness concern for civic amenities such as wells and drains, with the result that their cities apparently attest to alleged social egalitarianism, where the political power was less centralised and probably more corporate. This gives the impression of a society with relatively low wealth concentrations.

With many of their products being standardised through advanced craft specialisation, and widely distributed, close similarities in pottery, brick sizes, weights and measures, and seals

show strong evidence for a shared ideology. The Indus Script, albeit undeciphered, offers proof of a particular level of literacy, possibly indicating the existence of a form of administrative system that oversaw or possibly managed the economy. It seems to be an unusual example of an early heterarchical state which developed without any strong and centralised social control or evidence of structural violence.

As for the expression of wealth, Paul Rissman has argued that hordes of valuable objects are essentially private and secular deposits, while grave deposits are public, ritualised objects and ideological in nature. Funereal wealth, where it can be identified, was usually not comprised of objects commonly found in hoards and was of low relative value. The unequal distribution of secular wealth was veiled by an egalitarian ideology, one that permitted all social segments to participate and compete in public, if not in private, contests of status display.[18]

While it is necessary to re-emphasise that there is no material evidence for a ruling elite, there is certainly a suggestion of some centrally directed organising influence within the society and this poses several questions that remain unanswered. For example, who managed the demand for raw materials, food, and finished products, which required a highly sophisticated integration of its widely dispersed settlements? Who oversaw foreign sea-borne and land commerce? How was the uniform writing system, the system of weights and measures and even the standard size of bricks maintained and enforced or maintained? Although there seems to be no evidence to suggest the existence of either elites or a conspicuously impoverished under-classes, it leads one to suspect that efforts were expended to prevent such differentiation emerging.

Mark Kenoyer supports the concept of a state based on the Indus Civilisation, characterised by what he calls differing integration levels. At the highest level, encompassing the whole region there would have been competing classes of elites, maintaining different levels of control and interacting in the political, economic, and ideological spheres. The large urban centres, such as Harappa and Mohenjo-daro, may have been independent city states with control only over their own polity, developing in the Mature Harappan economic and perhaps even political integration through trade and gift exchange of status items. Instead of an elite, perhaps a royal dynasty, with absolute control, power would have been exercised by a group of merchants, religious officials and those who controlled land, raw materials, and, especially, cattle. They probably exercised this control by different means, but they would have shared a common ideology and culture, expressed in the manufacture and decoration of seals, ornamentation, pottery, and other artefacts. In the cities, society may well have been more rigidly stratified, and even segregated, than in rural settlements, where political organisation might have been manifested in chiefdoms and tribes.[19] Walter A. Fairservis, Jr. has suggested that, although elites did exist, they were identified with rural chieftains who could be found in

[18] Rissman 1998: 209-227.

[19] Kenoyer 1994: 77. This alternative view is supported by one which has Harappa and other major Indus urban centres likely occupied by peoples of different ethnicities and social groupings. Although these centres lacked the temples, palaces and burials that are usually indicative of status, evidence that a high degree of social stratification and differentiation did exist and is found in many forms, including possession of personal adornment, inaccessible to all members of society. Power and social standing could have been created and maintained through control of critical resources, which included land, livestock and commodities, assisted by ties with kin or clan relations or through interaction with nomadic communities and other migrating ethnic groups; see Law 2006: 301-302; and Khan 2016: 1-9.

the countryside, surrounded by the real symbols of wealth, namely herds of cattle,[20] but this is only speculation; the truth probably lies elsewhere.[21]

Massimo Vidale has expressed a very intriguing view that instead of being dominated by a single palace or temple, major urban centres included within it several walled compounds enclosing elite buildings, signposted by elaborate doorways made of carved pillars, where elite groups shared a similar ideology and microculture, but competing for prominence and socio-economic power. He also supports the idea that this period might also have witnessed the genesis of the caste system.[22]

A complex ancient society needs a focused leadership; but for the Indus Civilisation, we have no idea of how it was achieved or maintained. One thing on which we can agree, is that there is no evidence from the Mature Harappan period for war, or other form of conflict or even images of war. Wars and armies usually require central organisation, resources, deployment and command and control. Without such a centralised authority the Indus Civilisation was likely to have been a grouping of culturally and commercially connected and related city states. What we simply do not know is the nature of the relationship between the biggest urban centres – Mohenjo-daro, Harappa, Rakhigarhi.

One answer to the question of hierarchy, at least in the Late Harappan, lies in the work of Gwen Robbins Schug and her colleagues. They point out that at Harappa in the Late Harappan there existed strong differences in the risk of violent injury among different burial populations, suggesting that aspects of individual and community identity shaped the risk of this violent injury.[23] This tends to contradict the accepted view that the Indus Civilisation was peaceful and that vulnerability in the society was determined through a process of structural violence, unequal power, uneven access to resources, systematic oppression and exploitation that kills through the denial of basic needs and outright violence. An examination of differences among burial areas could provide additional support for that hypothesis.[24] However, this may only have applied to the Late Harappan, a period of decline and probable tension and rivalry.

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[20] Fairservis, Jr. 1986: 43-50.

[21] There may have been several different and competing elite groups who exercised control in different ways. Some were perhaps those who controlled inland or overseas trade, perhaps religious officials, or those who owned or controlled the land, livestock, and access to raw materials. They likely controlled the economy and society in different ways but shared a common ideology and economic structures; see Allchin and Allchin 1997: 187-188. Of course, the invisibility in the archaeological record of elites, or even a ruling family, in contrast to the Near East or Egypt is greatly enhanced by the absence of deciphered texts. Also see *Retrospect*: 173-183. Associated with this is the absence of militarism, warriors, and an extensive array of weapons, as is found in the Near East and Egypt at this time. Contrary to this viewpoint, Edward Cork has tried to demonstrate, however, that the Indus Civilisation may not have been as peaceful and egalitarian as has often been described. From an analysis of the weapons found at various sites, he has shown that, in comparison with contemporary societies, such as the Near East, they appear to be less warlike only because weapon assemblages are almost exclusively derived from settlement finds and not from cemeteries as in the other civilisations (Cork 2005: 411-423). On the matter of warfare, some believe there is evidence from the Mature Harappan. This includes evidence from Kalibangan, where there are clay-baked ballista, obviously for a slingshot, found on the parapet of the citadel wall of Mohenjo-daro. There are also *c.* 300 stone slingshots that were lying around in the ruins of the small fortress of Surkotada, in eastern Kutch. The massive and defended citadel of Dholavira, is a powerful argument against the assertion that there was no warfare, see Professor Shereen Ratnagar, interview, November 2016. One remains to be convinced, although it is accepted that the Gujarat fortified sites put paid to any notion of the absence of warfare or defence architecture. At Surkotada there is a destruction level that precedes the building of the fortifications, but all these examples could be the response to a localised threat.

[22] Vidale 2010: 72-73.

[23] *Peaceful Realm?*: 144-145.

[24] *Infection*: 3.

Going further than the ideas of Kenoyer and Vidale, it has been suggested that Indus Civilisation cities were governed not by an elite class, or by competing elite groups which led to the construction of high walls around the mounds, water management practices and presence and patterning of artefact types.[25] It has been proposed that given the large population size of the city, the majority of Harappans were not interred in its cemeteries. Of those buried in Cemetery H during the Late Harappan, a small contingent of human crania, 50% of which demonstrated evidence for traumatic injury, were disposed of in an ossuary outside the city;[26] perhaps they were warriors. Evidence for social differentiation and exclusion at Harappa indicates that even if organisation on a larger scale was relatively weak, social differentiation and control were exercised locally within the city itself.[27]

However, it must be admitted that none of the evidence that suggests the existence of elites is convincing and that the last word must go to Adam Green, who believes that the cities were expansive and planned, which involved large-scale architecture and sophisticated technologies. Despite these indicators of social complexity, they lack any evidence for elaborate tombs and monuments, large temples, or palaces, and supports Marshall in his belief that the Indus Civilisation was more egalitarian than other early complex societies. Green also points to the absence of evidence for a ruling class of managerial elites and a lack of political and economic inequality. He argues that a ruling class is not a prerequisite for social complexity.[28]

Regionalism

It is also important, as Possehl points out, to emphasise that whilst the Indus Civilisation was not as uniform and homogenous as previously understood, there certainly appears to be an element of cultural and social uniformity within the Mature Harappan, but the civilisation epitomised by Mohenjo-daro is not the same at other sites, e.g. Harappa, Rakhigarhi, Kalibangan, Nausharo, and Dholavira. As one travels into Saurashtra from Sind, and further southwards into Northern Gujarat, cultural differences can be identified, distanced from centralising influences, with their own character and ideology; a blend of Indus Civilisation as a whole, with their own special view of the world and relationship with the civilisation's heartlands and even further afield.[29] This view confirms that there is unlikely to have been a centralised polity, based on one of the great cities.

Fully understanding the complexity of the geographical dimensions of the Mature Harappan is important if we are to understand the nature of the society itself. It originally had been perceived that there was almost a strict uniformity within the culture in pottery forms and decoration, technology, town planning, measurement, building construction, and much more. Elements of this are true, for example, in terms of subsistence economy; the predominance of cattle at every region is something they all have in common and provides continuity and a social identity to the whole civilisation. This uniformity has perhaps been greatly exaggerated, and that change and evolution are clearly recognisable during both the Mature and Late

[25] Kenoyer 1991a: 331-338; Kenoyer *et al.* 2013: 2286-2297.
[26] *Peaceful Realm?*: 144-145.
[27] Possehl 1998: 261-291.
[28] Green 2021: 153-202.
[29] *Contemporary Perspective*: 249-250.

Harappan phases. As research into the Indus Civilisation has progressed, according to Possehl, it has become apparent that the differences in the subsistence economies of different parts of the civilisation, dependent upon differing natural area environments, are reflected also in culture, craft and technology, and what now emerges is a regional, cultural mosaic.

According to Possehl, the region of the Indus Civilisation can effectively be broken down into specific areas: (a) East Punjab Harappan, centred on Rakhigarhi and Banawali, and to which can be added other sites in Haryana; (b) Bahawalpur Harappan, centred on Harappa and Kalibangan; (c) Late Kot Diji, centred on Rehman Dheri; (d) Sindi Harappan, centred on Mohenjo-daro, Naushero, Chanhu-daro, and as far south as Surkodata; (e) Kulli Harappan, centred on Sutkagen Dior and Kulli; and (f) Sorath Harappan, centred on Rojdi, Lothal (which also includes elements of (d) above) and Rangpur. Again, whether they were in their time also roughly defined provinces of some greater political entity we cannot determine, but this cannot be entirely ruled out.[30]

Urban and Rural Settlements[31]

A sophisticated and technologically advanced urban culture is evident (Table 3) and the cities symbolise the ability of a society to mobile huge labour resources in building them. The huge brick walls of the citadel at Mohenjo-daro, with its platform, may have taken something like 10,000 building workers well over a year to complete. It also points to knowledge of early urban planning and perhaps a form of municipal government. As seen at Harappa, strikingly at Mohenjo-daro and the recently partially excavated site of Rakhigarhi, this urban plan included the world's first urban sanitation systems (see Chapter 6).

Of the Mature Harappan sites which have so far been excavated, only a few are large urban centres and a small number can be identified as towns. The remaining settlements fall within different categories, e.g. small or big villages, manufacturing centres, ports and a settlement, Shortughai, to control the exploitation of local natural resources. Other than Ganweriwala, all the sites have been excavated, producing impressive amounts of evidence for various aspects of their society, such as trade, society, religion, and the economy. The study of the major urban centres has enabled only a partial reconstruction of urban life, probably a small proportion of the total population. We have very little idea of rural lifestyle, where much of the population lived. This is partly due to very few small sites having been subjected to systematic excavation.

It was originally thought that the Indus Civilisation built their cities on a grid pattern, but on closer examination, while they were certainly planned, this was on an individual basis and, when compared, do not closely resemble each other; there is no immediately identifiable inter-settlement conformity of ideas in town planning. This also applies to the building materials used: many structures were built entirely in brick – both mudbrick and kiln-fired or burnt. Indus Civilisation cities were, however, not, as a rule, uniformly made of fired bricks. In fact, Mohenjo-daro is the only city where fired bricks were used in any great concentration. There is certainly some fired brick at Harappa, used for drains, the lining of wells, bathing

[30] Possehl 1992: 237-244.
[31] For general introduction to the formation of major urban centres, see Chakrabarti 1997.

Table 3. Archaeological criteria for determining urbanism (after Childe 1950: 3-17).

ARCHAEOLOGICAL CRITERIA FOR DETERMINING URBANISM		
1.	Comparatively Large	Yes
2.	Some full-time economic specialists	Yes, as assessed through archaeological remains of crafts such as bead-making and seal-carving that required sophisticated knowledge of physical properties
3.	Tithe or taxation	Unknown
4.	Monumental architecture	Yes. For example, the walls at Harappa and Dholavira and the Great Bath at Mohenjo-daro
5.	Ruling class/elites	Believed to be egalitarian
6.	Recording system	Unclear. The Indus Script may be a recording system or a validating system or even just a ritual series of signs
7.	Exact and predictive sciences	Standardised weight system
8.	Artistic or stylish expression	Yes. There is a stone and metal sculptural tradition, but there are also abundant terracotta arts including pottery and highly developed ornament manufacturing
9.	Long-distance exchange/trade	Evidence of trade with the Gulf and Mesopotamia and significant regional trade for durable goods and commodities
10.	Resident craftsmen subservient to political authority	Unclear. The location of craft manufacturing areas suggests possibility of control, but uncertain

[Based on template by Childe 1950: 3-17]

platforms, and such like, but it is not the predominant building material, which is mudbrick. In some other cities there was no use of baked brick, e.g. Dholavira, Lothal, and many more.[32]

Returning to the so-called citadels, many built on brick platforms are quite enigmatic as to their use. They originated in the Early Harappan when they were simply walled compounds and developed into something more sophisticated in the Mature Harappan phase. In the case of some of the larger, and even the not so large urban settlements, there are both the citadels and a structured lower town. At Kalibangan, where there is the element of formal town planning, there is a well-defined citadel mound, but during the Mature Harappan (Kalibangan II), we also see evidence under the citadel mound, of a 4.5 ha settlement enclosed within a 1.9 m thick wall. The parallelogram-shaped site includes mudbrick structures oriented north–south and laid out in courtyard fashion. At Kalibangan, nowhere is the continuity between the proto-urban stage (Kalibangan I) and the urban Mature Harappan phase (Kalibangan II) more in evidence. The city is well represented by the citadel mound to the east and the lower town compound to the east. The earlier Early Harappan settlement (Kalibangan I) followed exactly the same plan.[33] In fact, mudbrick only has a life of 20-30 years before it needs to be replaced. Dholavira is mostly made of local stone, readily available. Brickwork, however, is also limiting and therefore few, if any buildings at Mohenjo-daro were more than two floors high.

[32] *Contemporary Perspective*: 99-100, 247-248.
[33] Thapar 1973: 85-104; Lal *et al.* 2003.

The walls of Indus Civilisation cities, built using fired bricks, were most likely to be a protective, i.e. by diverting flood waters. Where bricks were used, they are all a standard dimension and road widths within the cities also confirm to a standard and usually run on a very loosely defined north–south or east–west axis. Houses opened only to inner courtyards and smaller lanes. The advanced architecture is shown by their impressive warehouses, brick platforms, and protective walls. Within the city, individual homes or groups of homes obtained water from wells. From a room that appears to have been set aside for bathing, wastewater was directed to a series of covered drains, which lined the major streets.[34]

What the high mounds and elevated platforms of major urban settlements, which were separate to the lower towns, such as at Mohenjo-daro, Harappa, Rakhigarhi, Kalibangan, Dholavira, and to a lesser extent Lothal, were used for, we do not know; they were certainly not defensive citadels, and there is no evidence of an elite dwelling. As Possehl points out, there is no consistency in the town planners' use of elevation as part of a civic design, and the mounds are clearly constructed within a wider retaining wall,[35] from where several of the earlier excavations assumed their citadel status.

Some larger nearby buildings were originally thought to have been granaries, and the largest such building at Mohenjo-daro measures 45.7 m long and 15.23 m wide. At Harappa, there are six of them, albeit smaller, with one on Mound F thought to be a dye works (see Chapter Four), and at Kalibangan there are brick platforms that may have served a similar purpose. In fact, there is no evidence that the so-called granaries were such and may well have been general warehouses.[36] Whatever they were, they all likely performed an important role in social storage.

Many city dwellers appear to have been associated with an urban economy, as traders or craftsmen, such as potters, brick-workers, spinners, weavers, bead makers, shell-workers, metalworkers, seal carvers, food producers and many other occupations, who lived with others pursuing the same occupation in well-defined parts of the city, although there must also have been administrators and scribes, or other occupations, i.e. boatmen. Although some houses were larger than others, almost all had basic access to water and drainage facilities. The hydro-engineering of Mohenjo-daro is unparalleled in the ancient world; the city is estimated to have had *c.* 700 wells, constructed with tapering bricks so strong that many have not collapsed in 5000 years.

Technology and Craft Industries

The very origins of Indus Civilisation technology can be traced back to the Final Neolithic (Mehrgarh III), when copper-based metallurgy first emerged, together with wheel-made pottery and bead-making technology, becoming a major feature of the society for nearly 2000 years. From these early roots developed major, semi-industrial modes of craft production, centred on the major urban centres. However, there is no archaeological sequence in which we can detect the first alloying or complex casting, as we can with Indus pottery, seals, and terracottas.

[34] For overview of domestic and public architecture, see *Tradition*: 353-354.
[35] *Contemporary Perspective*: 101-104, 247.
[36] *Contemporary Perspective*: 101, 247-248.

One unique feature of the Indus Civilisation is its standardised system of weights and measures, a combined binary and decimal system, referred to as the 'Indus weights,' which would have facilitated several activities, such as trade, and were vitally important in the development of administrative systems in these early complex societies. The most common of the Indus weights are chert cubes of *c.* 13.7 gr. Below this, the weights descend in a simple binary system; the smallest unit weights are 0.865-0.871 gr, one sixteenth of 13.7 gm. Above this weight, units increase decimally. The largest is 1.37 kg, one hundred times the basic unit. To complement the weights, some copper balances have been found at several sites, although it is possible to identify regional variation.[37]

The recent analysis of a crude terracotta scale of length found at Kalibangan, suggests that there was a basic unit of measurement of 17.63 mm. Found with the scale were a terracotta hour-glass, plumb-bobs of terracotta, faience and shell, terracotta pans for balance weights and the weights themselves.[38] In addition, they evolved some new techniques in metallurgy, utilising copper, bronze, lead, and tin.[39] A touchstone bearing gold streaks was found at Banawali, used for testing the purity of gold.[40]

Indus Civilisation tools and utensils offer a strong impression of almost obsessive uniformity. Unfamiliar with the use of iron, they worked using a standardised kit of tools made from bone, chert, together with copper and bronze. The Saurashtra region also had access to other natural mineral resources, e.g. carnelian, agate, chert, and all semi-precious stones, used either for bead or tool manufacture. The most important source of chank shell (*Turbinela pyrum*), one of the three sources in the Indus region was along the Saurashtra coast in Gujarat, an important raw material for the manufacture of bangles and beads. Shell processing centres, such as Nageshwar on the western tip of Saurashtra, were established for the production of beads and bangles (for supply to the domestic as well as the international markets).

Other resources, such as copper, can be found in the Khetri belt in Rajasthan, although some may also have been obtained in Baluchistan or from the Gulf. Gold came from the Hatti mines in South India, and gold, tin and lapis lazuli were obtained, with much difficulty, from the Badakhshan region of north Afghanistan, all three located well away from the core of the Indus Civilisation but controlled by it. By developing effective communication networks and exchange mechanisms it was possible to manage a constant flow of essential raw materials and an uninterrupted distribution of finished goods to the Indus population and further westwards.

Various sculptures, seals, gold jewelry and anatomically detailed figurines in bronze and steatite (soapstone) have been found at most sites, the most important being the so-called 'priest king', made from steatite, from Mohenjo-daro (DK1909).[41] A number of bronze and stone figurines of girls, in what some believe to be dancing poses, reveal the presence of dance forms; the most famous is the diminutive, naked dancing girl in bronze from Mohenjo-

[37] Wilkinson 2014: 146-147, fig. 4.13a and table 4.1.
[38] Balasubramaniam and Joshi 2008: 588-589. For Indus metrology, see Ratnagar 2003: 79-92; and Kenoyer 2010: 106-121.
[39] For review of craft technology and specialisation, see *Tradition*: 356-358; *Contemporary Perspective*: 93-98.
[40] Bisht 1982: 113-124.
[41] National Museum of Pakistan, Karachi, inv. No. 50.852. For discussion, see *Contemporary Perspective*: 114-117 (see front cover).

daro (HR-5721).[42] Many major crafts, such as shell-working and agate and glazed faience, steatite and carnelian bead making, were used in the making of necklaces, bangles and other ornaments.[43]

At most Mature Harappan sites were found thousands of small square and rectangular seals and their clay impressions, invaluable in helping to understand the economy, trade and, to a limited extent, the religion of the Indus Civilisation.[44] They were usually made from steatite and carved in intaglio, with the finished seal baked to harden its surface. The images were often very complex motifs of human figures, animals (some possibly deities), and a uniform and developed script (see below); sometimes the animals were hybrid, either of different animals or humans and animals, the importance of which is not yet fully understood. Some of the seals were used to stamp clay sealings on trade goods, but many probably had other uses.[45] They also made various toys and games, among them cubical dice with one to six holes on each face, familiar to us today, which were also found at Mohenjo-daro.[46] Other known craft skills include the manufacture of fired and non-fired bricks, bricklaying and textiles, including the production of cotton and wool garments.

Nearly all the phases of the Indus Civilisation produced high-quality pottery, characteristically bright or dark red and uniformly sturdy and well fired, consisting mainly of wheel-made wares, both plain and decorated, with the plain ware being the more common, usually of red clay with or without a fine red slip. It is believed that the potter's wheel was first introduced by the beginning of the Early Harappan. The forms include goblets, dishes, basins, flasks, narrow necked vases, cylindrical bottles, tumblers, corn measures, spouted vases, and a special type of dish, probably an offering stand or incense burner. The painted pottery is specifically of red and black colours, much of it light-on-dark, decorated with a mixture of geometric motifs (circles, squares, triangles), various figures of animals, (birds, snakes, fish), and the common motif of the tree pattern. They also produced incised, perforated, and knobbed wares.[47]

Important to their society were the ubiquitous terracotta human male and female figurines, dating from the Early to the Mature Harappan phases, some of which had red colour applied to the manga, at the line of partition of the hair.[48] Animal figurines have also been found and include bovines of various types, rhinoceroses, bears, a tortoise, monkeys, dogs, as well as many birds. These anthropomorphic and animal figurines range in size from slightly larger than approximately 4 cm to *c.* 30 cm in height; they also offer a rich representation of everyday life in the period, in particular representations of ox and water buffalo carts. However, they remain enigmatic; some have considered them as toys, but this is unlikely. They are likely to be quite significant in religious and ritual terms, and some as instruments of a healing cult (see Chapter 7).

The Indus Civilisation, with its major urban centres or cities, as well as being likely centres for administration and religion, were also major centres for trade and craft production. In the

[42] National Museum, New Delhi; see *Contemporary Perspective*: 113-114.
[43] Kenoyer 1991c: 262-280. For a summary of Indus faience manufacture, see Polinger Foster 1979: 27-34.
[44] *Forgotten Cities*: 179-187.
[45] *Contemporary Perspective*: 127-131.
[46] Dales 1968: 14-23; *Contemporary Perspectives*: 224.
[47] *Contemporary Perspective*: 90-93.
[48] *Contemporary Perspective*: 117-122. See also Clark 2003: 304-328.

workshops, which were located both in the centre and at the periphery of the cities, there was the development of very distinctive styles of utilitarian and ornamental or symbolic objects. Those which are profiled more clearly in the archaeological record include pottery, beads, bangles, metal tools, figurines, and other objects. We must also not ignore those crafts that are lost to us, their materials being organic and tending to decay in the ground – leather, wood, fabrics (wool, cotton, silk), and basketry.

Some were made for the local market and much of the production in black-on-red painted pottery, carnelian and steatite seals and beads can be found throughout the region and further afield. What we also cannot lose sight of are regional variations, and that individual settlements may have been the source of craft objects. The standardisation of weights, measures and some seals are likely to be attributable to centralised control in some form, whereby pottery, metalworking and ornaments may have been standardised simply by demand and a shared culture and ideology and used for trade and cultural exchange.

Kenoyer has pointed out that to understand the differing roles of craft in the Indus Civilisation it is important that we distinguish four categories of craftsmen who worked at Indus sites: (a) those processing local materials using simple technology, such as woodworkers, builders and those who produced terracotta objects; (b) those using imported materials with simple technology, such as chipped stone, ground and pecked stone; (c) those using local materials, but having more elaborate and complex technologies, such as stoneware bangle makers, potters who made fine wares, those who practice wood inlay; and (d) those using imported materials, but with complex technologies, such as agate bead makers, seal carvers, copper and bronze workers, those who used precious metals, shell workers and faience workers.[49]

In the manufacturing process, recent research points to the production of some special objects, such as seals, stoneware bangles and carnelian beads having been separate from other crafts and are found concentrated in parts of the settlement for purposes of production, safety, and the access to water, materials, and even labour. More specifically, several factors might affect spatial associations among production areas for different crafts. The groupings of craft production seem to have been predicated by other important factors such as: (a) the nature of the craft, whether a particular process is required, such as the use of fire and high temperatures; (b) knowledge relationships and manufacturing requirements within the groups; (c) what constituted distinct crafts, the value of the goods produced and the likely consumers; and (d) ideological beliefs concerning the proper placement of manufacturing within city centres.[50] To this we can add environmental factors, such as the avoidance of unpleasant smells.

Burial Customs

Despite intensive archaeological activity for nearly a century, burial evidence is recorded from only a few sites, i.e. Harappa, Derawar, Ropar, Rakhigarhi, Kalibangan, Farmana, and Lothal.[51] At Mohenjo-daro, the largest Indus Civilisation settlement, only 38 skeletons were found

[49] Kenoyer 1992: 39-54.
[50] Miller 2008: 37-51.
[51] *Burial Practices*; *South Asia*: 111-113; Singh 1970: 8-13. For an additional view of burial customs, see Dibyopama *et al.* 2015: 1-9.

intramurally in different parts of the Late Harappan city, but there is, as yet, no suggestion of a cemetery:[52] it must lie outside the walls, buried under very deep layers of silt.

The site of Harappa produced the first two discovered cemeteries – Cemetery R-37, from the Mature Harappan, and the largely Late Harappan phase Cemetery H. The earlier Cemetery was constructed systematically and is located near Area R, where 91 graves have been found; some were disturbed by later burials, although in the same stratum. The graves in Cemetery R-37 are pits, mainly oriented north–south and the size varies, usually being determined by the number of grave goods which accompanied the burial. The dead were usually laid in an extended position on their back, occasionally on one side or the other, with nearly all the heads being placed to the north. The grave goods were mostly well-decorated pottery, but a handled copper mirror, antimony rods, and some shell spoons are reported from some of the graves. The dead were also accompanied by personal adornment, such as finger rings, necklaces made from steatite or soapstone, beads, anklets of paste beads and girdles of semi-precious stones, earrings, and shell bangles. One grave has a coffin with traces of a reed shroud, with most of the burial pottery being found outside the coffin. However, there is nothing to suggest elite burials in any form.[53]

The later Cemetery H, located north-east of Cemetery R-37, discovered in Area H of Harappa,[54] has two strata with different types of burial. The earlier or lower group (Stratum II) are extended burials, where the dead were placed in the graves lying on their backs, in an extended fashion or with the legs slightly flexed; they show a clear cultural link to the Mature Harappan and cemetery R-37. In the later and higher stratum (Stratum I), which lies above the lower stratum, but extends beyond it to the west and south-east, we see the use of pot burials, and large, lidded ellipsoid carinated and pedestal footed pots or urns as containers for human crania and disarticulated long bones, which had previously been exposed. The pottery vessels were richly decorated with what appears to be funerary rather than decorative motifs, with an occurrence of peacocks and humped bullocks suggesting transport to the afterlife. The grave goods, exclusively pottery, are clearly characteristic of the Late Harappan.[55]

At Kalibangan, three different modes of burial have been uncovered in the cemetery, 350 m south-west of the citadel, where 34 graves were located. They are typical of burial customs of the period, except for the empty graves. Dated to the Mature Harappan (Kalibangan II), they are, firstly, extended burials, i.e. burials in rectangular or oval pits, with the inhumation laid down straight or extended, the head placed northwards and associated with grave goods, mostly pottery. In one pit a copper mirror was found among these objects. One pit grave

[52] *Burial Practices*: 198. At face value, all 38 skeletons suggest unnatural deaths. 13 were found in Room 74 of House II in Area HR and were a mixture of adult males and females and one child, lying in distinct positions. Six were found in a street in Area VS and another in a smaller street in Area HR. Four adult skeletons and five children were found in a pit in Area DK, and four more on stairs leading down to a well in Area DK-G.

[53] The earlier cemetery excavations remain unpublished. For the later excavations, see Wheeler 1947: 83-90; Mughal and Halim 1968: 144-152. Recent analysis of the physical remains from the R-37 cemetery at Harappa shows this was a restricted segment of society; the evidence based on the study of 84 females, indicating affinities amongst the female population and with the individual females buried in the later Cemetery H (Stratum II). This suggests that the people of Harappa may well have practised matrilocality – a system whereby couples move after marriage to the village or urban centre where the bride's family reside, the husband having come from outside both the community and the gene pool; Hemphill *et al.* 1991: 137-182; *The Ancient Indus*: 263-264.

[54] *Harappa*: 203-245.

[55] *Burial Practices*: 198.

was enclosed with a mudbrick wall, plastered, and with 29 small pottery vessels and utensils placed around the main urn. In some graves, beads, shell, and other small objects have been found. Finally, there are rectangular or oval grave-pits, containing only pottery and other small funerary objects, but no human remains.[56]

Like the first type, the orientation of these graves was also north–south. As the latter 'burials' are not associated with any human skeletal remains, they may be related to symbolic burials, something not encountered at other Indus Civilisation settlements. Other cemeteries have been found at Derewar and at Ropar, the latter having 13 Mature Harappan graves, most with the grave orientation north–west to south–east, but they contained the usual grave goods, and at Lothal, where 20 graves have been uncovered. Recent excavations at Farmana in Haryana have provisionally recorded a Mature Harappan cemetery comprising 70 graves.[57] This site is one of the few where a settlement and associated cemetery have been found together.

Indus Civilisation burial customs might be generally summarised as: (a) Only inhumation was practised, although it is possible that some may have been exposed first; (b) Graves are oriented north–south, with a few exceptions; (c) The dead were buried lying on their backs, in an extended position, with the crania to the north; occasionally they were placed on their sides with legs flexed or, in one or two cases only, with the knees bent up;[58] (d) Each grave usually contains only one burial, but there are instances of male-female double burials, perhaps husband and wife; (e) Most burials are accompanied by grave goods, mostly pottery, ranging in number from four to 40 per burial; occasionally other grave goods are found; body ornamentation was common, but there is nothing to suggest overtly elite burials; (f) In one burial at Harappa (Cemetery R-37) there is the use of a wooden coffin, which contained a reed shroud; (g) In very rare cases, animal sacrifice accompanied the dead;[59] (h) Speculation by some of the practice of cremation in the Mature Harappan is not supported by the evidence;[60] (i) Some were empty graves, other than for grave goods, their use is not yet fully understood.

Transportation, Trade and Overseas Contacts

There were obvious geographical limitations to the extent of the Indus Civilisation. They include mountains to the west in Baluchistan, which contain minerals and metals and were good for pasturing cattle; the Sind desert to the east, which partly limits contact with the rest of Asia and mountains to the north-west and north, the Hindu Kush and the Himalayas, which inhibited contact beyond. These were the Indus land boundaries. However, important to them and their economies were certain commodities (tin, gold, silver, agate, steatite, lapis lazuli) not found within easy reach of the Indus region and which had to be imported southwards, overland, facilitated by advances in transport technology.[61]

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[56] Lal and Thapar 1997: 79-88.

[57] Shinde *et al.* 2010. At the Mature Harappan necropolis of Rakhigarhi, excavations were undertaken between 2013-2016 to determine the different types of burial customs used in the period. Of importance was that some graves displayed evidence of prone-positioned internments, see Shinde *et al.* 2018.

[58] *Burial Practices*: 206.

[59] *Burial Practices*: 206.

[60] *Contemporary Perspective*: 152. There is a suggestion, however, of a crematorium in Tarkhanwakla Dera in Rajasthan (Ghosh 1962: 1-5), but it is unconfirmed.

[61] For or an overview of both internal and external trade and exchange, see *Trading Encounters*; and *Tradition*: 358-361.

The Indus Civilisation was linked internally by some roads and, particularly, by river and sea-going vessels.[62] Life was semi-amphibious; the plain by Mohenjo-daro was often a vast lake of water, regardless of the brick flood-barrier, 7 km to the east, which diverted the main flow of the River Indus away from the city. The river was navigable over much of its length, so ships could sail between cities of the Indus Civilisation and thus encouraging communication, trade and exchange, as well as passengers. As far as the vessels themselves were concerned, they were probably small, sea-going, flat-bottomed craft, particularly those that were plank-built, equipped with a single, central mast supporting a sail of woven rushes or cloth.[63] Towards the end of the Early Harappan and during the Mature Harappan phases significant developments in water traffic made it possible to transport heavy loads along the rivers and to expand direct sea trade much further afield. At Lothal there has been found what was thought to have been a massive, dredged canal, which some regard as a docking facility at this coastal town, but this is disputed.[64]

Land transport was dependent upon the ubiquitous ox-drawn wagon, and they may have even invented the solid wheel and wheeled transport, although overland trade and contact between the Indus Civilisation and the Iranian plateau, Central Asia, and Mesopotamia is likely to have been conducted by caravans, passing through several major centres on their way.

During the earlier Pre-Harappan phase, the Indus region shows similarities in pottery, seals, figurines, and ornaments with Central Asia and the Iranian plateau,[65] which suggests mobility and overland trade. Judging from the dispersal of Indus artefacts, the trade networks economically integrated a huge area, including portions of Afghanistan, the coastal regions of Iran, possibly the Elamite homeland, and northern and western India.[66] The recent study of the skeletal remains of a young female discovered in a burial jar at the site of Chanhu-daro in the 1935-1936 excavation season points to her having African origins, as well as to trade and human and cultural exchange in the 3rd millennium BC with the north-east African coast.[67]

We know that a maritime trade network operated between the Harappans and Mesopotamia and the Gulf. Much of it was handled by merchants from *Dilmun*, associated with modern Bahrain or the Kuwaiti island of Failaka, or from *Magan*, likely to be the Umm an-Nar sites located on the Makran coast of Oman, where Mature Harappan material has been located.[68] Over 30 Indus seals and other materials of the same origin, such as carnelian beads, have been found in the Gulf and the Near East.[69] Some Near Eastern material has been located at Harappan sites, including a seal which owes its origins to the Gulf and was excavated at the Harappan port town of Lothal.[70] This trade or gift exchange was for the likely export from the Indus Civilisation of objects of gold, timber, elephant ivory, carnelian, agate and other semi-

[62] Kenoyer 2008: 80-104.
[63] *Trading Encounters*: 212-245.
[64] This feature at Lothal was identified as a dockyard, see Rao 1979: 123-136. However, several scholars believe it simply to be a tank (i.e., see Leshnick 1968: 911-922; and Pandya 1977: 99-103. See also Mathur 2002: 61-67.
[65] *Contemporary Perspective*: 229-235.
[66] There is growing evidence that more ordinary goods, ranging from textiles to food, were transported over long distances, see *Trading Encounters*; 106-211; Lawler 2009: 717.
[67] Kennedy and Possehl 2012: 169-180. See also *Chanhu-daro*: XCIV.
[68] *Trading Encounter*: 20-85; Lamberg-Karlovsky 1972: 222-229; Parpola *et al.* 1977: 129-165; Edens 1992: 118-139; Franke-Vogt 1993: 72-97; Potts 1993: 423-440; *Contemporary Perspective*: 215-228; Possehl 1997: 87-100.
[69] *Contemporary Perspective*: 221, Table 12.4.
[70] *Contemporary Perspective*: 226-227; *Trading Encounters*: 94-98.

precious stones, and goods such as cotton, silk,[71] dyes, coloured garments, high quality wool, and exotic livestock, such as apes and peafowl. There are black-slipped jars which may have carried liquids, as well as commodities such as tin and lapis lazuli. Several additional coastal settlements now located in modern Pakistan, like Sutkagen-dor (on the Dasht River, north of Jiwani), Sokhta Koh (on the Shadi River, north of Pasni), Balkot (near Sonmiani), testify to their role as Indus Civilisation trading ports, with shallow harbours, located at the estuary of rivers opening into the sea, allowing for a brisk maritime trade.

The major outlet to trade from the Indus Civilisation in the south seems to have been centred upon the Gujarat. For example, the site of Dholavira in the Rann of Kutch during the Mature Harappan witnessed the building of an urban centre with many of the usual features, and extending over 100 ha, but also being provided with a large fortification wall. Although a distance from the Indus heartland, Dholavira may be one of the critical links between the centre of the Indus Civilisation, the Gulf, and Mesopotamia in the 3rd millennium BC. We are reminded that maritime connections further afield have been confirmed by the finding of Indus seals and artefacts in the Gulf and in Sumerian port cities, e.g. Ur. Although evidence of foreign material from Harappan sites is quite scarce, seals from the area around Bahrain (*Dilmun*) have been found at Lothal.

Excavations at the fortified village of Kanmer,[72] that in the Mature Harappan had a likely population of 400-500, have discovered a wall, 20 m thick and 10 m high, inside which there was evidence of the manufacture of carnelian, lapis lazuli and agate beads that were used in jewellery exported across the region. In recent years, dozens of Harappan sites have come to light in this coastal region of Gujarat, which was once considered a periphery of the Indus Civilisation's heartland. Fortified sites, such as Kanmer, are rare elsewhere in the Indus Civilisation; they could be a sign of conflict and a need to protect their heavily controlled and regulated craft industries from attackers by land or sea. What we do not know is who constituted the potential threat. These centres were an important link in the chain of trade that stretched from the Himalayas to Mesopotamia, and we need to know who built and sailed the ships that connected these ports with the Gulf and Mesopotamia.

The Mature Harappan phase is contemporary with the Early to Middle Bronze Age in Mesopotamia, in particular the Old Elamite period and Early Dynastic to Ur III.[73] In Mesopotamia the Indus Civilisation has been identified with the toponym *Meluḫḫa*, which features in the Akkadian records, as does the cargoes its ships carried.[74] Evidence points to traders from all these regions meeting at sites in the Gulf for carrying out business trade and exchange of goods, being centrally located, although it is most unlikely that merchants from these cultures travelled directly to each other's homelands. The sites in the Gulf and Mesopotamia were also stepping-stones for Harappan objects travelling further west.

[71] Recent microscopic analysis of archaeological thread fragments found inside copper-alloy ornaments from Harappa, and steatite beads from Chanhu-daro, have yielded silk fibres (for threading beads), dating to *c.* 2450-2000 BC, see Good *et al.* 2009: 457-466.

[72] Kharakwal *et al.* 2007: 21-47.

[73] What is surprising is the lack of evidence of a close trading relationship with the Elamites, with its closer proximity than Mesopotamia and considering the needs of the Indus Civilisation for wood, stone, and metals. This may be due to the Persian coast being of less importance than the ports to the west side of the Gulf, owing to the nature of the coast itself and its inhospitality. See *Trading Encounters*: 27-33.

[74] *Trading Encounters*: 24-27, 98-102; Franke-Vogt 1993: 77; Possehl 1997: 87-100.

Whether Indus Civilisation contact with the Eastern Mediterranean was intentional is most unlikely, but trade and exchange from that region with Mesopotamia would have meant that some of the objects, often considered exotic, and traded through the Gulf and the Rivers Euphrates and Orontes and later Mari, would sooner or later have moved on. Much of the evidence is quite scanty and only relatively few objects, e.g. the carnelian etched bead and the silver flat disc-shaped beads found on Aegina in the prehistoric Aegean (Kolonna period VI, *c.* 2200 BC) are positive evidence of this indirect contact. No clearly Aegean objects, for example, have yet been found at any Harappan site.[75] Commodities such as tin, gold, and lapis lazuli were sourced by the Indus Civilisation at sites in northern Afghanistan around Badakhshan and traded by them southwards to their homeland and then westwards. Nearby, they built a town at Shortughai, which exhibits all the marks of a standard Mature Harappan settlement, to keep control. The Indus Civilisation likely imported, in return, bronze, silver, wool and woollen cloth, intricately carved stone vessels with mythological scenes, and the occasional pearl or mother-of-pearl item from Bahrein (*Dilmun*).

In population terms, heterogeneity in the major Indus Civilisation urban centres is to be expected, particularly in the context of population growth over time and their participation in a wide-reaching internal and overseas trade network. A heterogeneous composition at Harappa has been underlined by a very preliminary analysis of isotopic signatures in skeletons from the urban phase Cemetery R-37, some of which may demonstrate a non-local origin.[76] The isotopic data indicate that individuals buried in Cemetery R-37 shared some aspects of occupational, affinal, or consanguineal identity, but that 'Harappans' were quite diverse regarding their geographic origins.[77]

Towards the end of the Mature Harappan, trade would have been greatly reduced with Mesopotamia following economic decline. Around 1900 BC, the agricultural yields had fallen to about 35% per hectare of the yields achieved a thousand years earlier; the main causes being salinity and over-tilling. Ur and other southern cities now looked to the north. Lebanon supplied cedar wood, and metals other than tin were now sourced from the Zagros mountains and Anatolia. The Euphrates now became a busier trade route. This would also have had a major effect on the economy of the Indus Civilisation.

Agriculture

The Indus Civilisation owes much of its wealth to its long history of food production, dependent upon river water. The Indus floodplain, for example, was ideal for low-investment arable farming and cattle herding. Rivers regularly flood and form natural levees, as in Mesopotamia, making irrigation easy, with little need for artificial canals. Floods would come at a convenient time, bringing both water and rich silt, allowing for two crops per year. The evidence of the earliest farming communities comes from Mehrgarh, which points to early food production, and its development and gradual improvement, being an indigenous South Asian, or even an Indus region phenomenon.[78] Much as the evidence supports the process of urbanisation

[75] Relations between the Indus Civilisation and the Aegean are fully discussed in Arnott 2022.
[76] Kenoyer *et al.* 2013: 2286-2297.
[77] *Infection*: 3.
[78] Jarrige 1986: 63–131. For an overview of agriculture and subsistence strategies, see *Tradition*: 354-356. For an interpretation of the origins of crop and animal domestication in prehistory, outlining the contribution of South Asia, which include Early Harappan and the Southern Chalcolithic of Saurashtra, see Fuller and Murphy 2014: 1, 5-8.

and the development of complex social organisation, based on indigenous, but not isolated, cultural developments.[79] Here the origins of sedentary and pastoral life can be found. It is known that the people of Mehrgarh, as early as Mehrgarh I, used domesticated wheat and barley, and the major cultivated cereal crop was naked six-row barley, a crop derived from two-row barley. From this immense agricultural potential the civilisation both originated and sustained itself. Evidence also points to the early cultivation of pulses, sesamum and mustard, as well as wheat and barley, which were sown once the floodwater receded and thus did not require irrigation. Millett, originating in Africa, and rice were also grown, but the latter was of importance mainly during the Late Harappan and is attested at Lothal.[80]

A fragment of woven cotton cloth has been found at Mohenjo-daro and is the earliest evidence in the world to date of the growing of cotton.[81] There is also evidence of banana cultivation as early at Kot Diji in the Mature Harappan phase.[82] Other foodstuffs include pulses, oilseeds (including castor and sarson/mustard), methi and garlic, plus fruits and nuts, e.g. bel, jamun, lemon (and even possibly orange), grape, almonds, walnut, date, musk, melon, watermelon, etc., thus allowing for a varied diet. Vetch and clover seem to have served as animal fodder.

The Indus and Ghaggar-Hakra river basins are largely covered by alluvium and are some of the most fertile parts of South Asia, providing a solid agricultural base, where they could raise not only sufficient food grains for the population but also a surplus; they were particularly suitable for wheat and barley cultivation. They had under their control regions such as Saurasthra and North Gujarat, which are covered by black cotton soil and coarse soils respectively. The main crop cultivated in Saurashtra was millet, whereas North Gujarat has vast tracts of pastureland. Such varied ecological conditions gave the population of the Indus Civilisation considerable subsistence advantages. In the event of one agricultural zone failing due to a natural disaster, there was another at their disposal to support them and they did maintain friendly relations with neighbouring non-urban communities, both on the eastern as well as the western borders, to their mutual benefit.

Wide ranges of domesticated animals were kept for food, transport and agriculture, including Indian humped cattle, buffalo, oxen, sheep, goats, pigs, domestic fowl, elephants, asses, and camels.[83] The non-domesticated animals hunted for food, skins and other products, included wild camels, boar, rhinoceros, tigers and various forms of deer, i.e. the ibex, which inhabited the forests alongside the rivers of the region and beyond the alluvial plains into the deserts. The humped zebu (*Bos induicus*) was probably the result of the domestication of the eastern line of the wild aurochs (or wild bovine), from whence it later spread further into India. Domestic dogs and cats, used for pest control, were known, and there is evidence from numerous seals that tigers were familiar and are likely to have been hunted for their skins. Fishing in the rivers and the sea was commonplace, with catches providing a major source of protein.

For a more recent study of the rural economy, see Parikh and Petrie 2019.

[79] Schaffer and Lichtenstein 1999: 245.

[80] For African millet, Possehl 1986: 237-256; Weber 1998: 267-274; *Contemporary Perspective*: 64. See also Fuller *et al.* 2011: 544-558. For rice, see Glover and Higham 1996: 414-419. There is also compelling evidence for a Middle Asian corridor of crop dispersal between China and the Indian Sub-Continent, and agricultural innovation from the 3rd millennium BC onwards, involving cereals, millets and rice, see Stevens *et al.* 2016: 1541-1555.

[81] *Contemporary Perspective*: 64. There is now evidence of the growing of jute, see Wright *et al.* 2012: 137-143.

[82] Fuller and Madella 2009: 333-351.

[83] Evidence for camels has been disputed; however, see Meadow 1984: 133-139.

As the Mature Harappan sites of Harappa, Mohenjo-daro, and many others, were in serious decline, or being abandoned, at the beginning of the 2nd millennium BC (*c.* 1900-1800 BC), the site of Rojdi (Roji C period) was experiencing a final period of occupation marked by expansion.[84] The increasing availability of additional palaeobotanical evidence of the Mature Harappan phase points to an increasing emphasis on a large number of species of subsistence crops and cropping practices in the changing subsistence economy of the period, with the intensification of agriculture going hand-in-hand with social and environmental change. It is also possible, from a comparison between Harappa and Rojdi, that there existed a substantial level of decentralisation and localisation and this may reflect shifts in the socio-economic structures of these societies; but the likelihood of a changing need to come to terms with a changing climate and water availability is more likely.[85] Of significance in the subsequent study of these samples has been an understanding of the way that African millets were introduced into the local agricultural system at the end of the 3rd millennium BC.

Based on the archaeological evidence of faunal remains, figurines and other religious imagery, cattle and pastoral nomadism played an especially important role in the lives of the population of the region. The emerging picture of rural life shows that many of the population were cattle herders and, given the vast extent of the Indus Civilisation cultural sphere, that the area provided a substantial base for regional interaction and communication, with the substantial number pastoralists filling the space between the urban centres. Rural society was a complex mix of farmers, herders, hunters, gatherers, and other different occupations, mainly dependent on arable and pastoral by-products.

Writing and Literacy

The Indus Civilisation was literate, but despite the efforts made to decipher the Indus Script it remains an enigma (Figure 3). If deciphered, some information on various aspects of their culture might become known to us.[86] The earliest use of the script is dated to *c.* 3300 BC and continues right until the end of the Late Harappan. Well over 400 distinct symbols of the Indus Script have been found, principally on seals, but also inscribed on small clay tablets or painted on pottery vessels, and a few more on other materials, including metal tools, bangles, small copper tablets with raised script and sealings (objects made from moulds with writing and graphic scenes), together with a possible signboard that apparently once hung over the gate of the inner citadel of the town at Dholavira.[87] The script is highly standardised; typical Indus Script inscriptions are usually no more than four or five characters in length, available

[84] Possehl and Raval 1989.

[85] Weber 1999: 813-826. See this paper for a general understanding of the increasing emphasis on a greater variety of species and agricultural practices in changing subsistence levels at the end of the Indus Civilisation, with agricultural intensification identified in relation to social, environmental, and climatic changes. Evidence is now emerging, using the evidence of starch grains, from the site of Farmana in the Indian state of Haryana, occupied from 2600-2200 BC, which shows that additional plant species were being exploited, but not necessarily preserved in the carbonised seed record. Starch finds have corroborated the existence of wheat, barley, indigenous millets, e.g. *Panicum* and *Setaria* and the South-West Asian pulse *Macrotyloma.* In addition, there is new evidence at the site of other tropical pulses, such as *Vigna* species, millets of African origin, vegetables such as cucurbits and eggplants, this being among the earliest evidence of the latter in South Asia, fruits such as mango and date, and roots and tubers such as *Dioscorea*, *Zingiber* and *Curcuma*. See Kashyap and Webber 2010.

[86] For reviews of the attempts at the decipherment and nature of the Indus Script, see Parpola 1994 and Possehl 1996. For shorter reviews, see *Tradition*: 361-364 and Robinson 2002: 264-295. For a report of the progress towards decipherment, see Parpola 2005: 26-88.

[87] Kak 1996: 275-279.

Figure 3. The Indus Script: seals and tablets (© J.M. Kenoyer/Harappa.com and courtesy of the Department of Archaeology and Museums, Government of Pakistan).

on seals and tablets, perhaps mainly meant for trade and commerce. Aside from the Dholavira signboard, some of the seals and sealings are small; the longest on a single surface, which is less than 2.54 cm^2, has 17 signs.

There is, however, some common ground amongst scholars on how the writing system worked. For example, it is believed that the script is, as a rule, written in regular lines, and should be read from right to left in the impressions (stamp seals represent reverse script as they were meant to be read only from an impression), although there are one or two cases where it is read left to right, as well as in the boustrophedon (continuous and alternating) form. It is believed that the script makes use of suffixes, but not prefixes or infixes; it is logosyllabic as the signs tell us that the script is not alphabetic; and it is unrelated to any other later Indian script and is impossible to have been the written form of an Indo-European language. In fact, we have no idea of the language family of this script. What we do know is that literacy was developed indigenously with the emergence of urbanisation.

The Indus Civilisation is characterised as a literate society on the evidence of these inscriptions. This view has, however, been challenged on linguistic and archaeological grounds, as it has been pointed out by some that the brevity of the inscriptions is unparalleled in any known pre-modern literate society. Some recent research argues that the Indus Script does not encode language but is instead like a variety of non-linguistic sign systems used in the Near East and other societies. It is quite possible to accept that the script was exclusively used for economic transactions, but this leaves unexplained the appearance of Indus Script symbols on terracotta and faience amulets, mass-produced in mounds.[88] No parallels to this form of inscriptions are known in any other early ancient civilisation.

Some computer scientists, comparing the pattern of symbols to various linguistic scripts and nonlinguistic systems and a computer programming language, found that the Indus script's pattern is closer to that of spoken words, supporting the hypothesis that the Indus Script hides an as yet unknown language,[89] although Asko Parpola is of the view that the language could be a form of proto-Dravidian.

Religion

Little is known about religion in the Indus Civilisation,[90] and what little there is proves difficult to interpret. It is not certain who ruled the cities or their structure of government, but it is unlikely to be a class of priest-kings, for which there is no evidence. In view of the considerable number of female terracotta figurines found, it has been widely suggested that the population worshipped a mother goddess symbolising fertility. Many seals show animals. The simple answer is, however, that we simply do not know. We do know that instead of images of deities in temples there were gods and spirits not in human form, but represented by the wind, a forest, or just a tree.

A Mature Harappan steatite seal found at Mohenjo-daro (DK5175), depicts what some believe is a deity represented as seated in a yogic posture surrounded by animals,[91] thought to be an elephant, a tiger, and a rhinoceros; below the throne there is a buffalo with two deer at its feet (Figure 4). The meaning of the image is highly speculative. Some have gone so far as to propose that it is an early representation of the god Shiva or a proto-Shiva, worshiped in the form of *Pasupati* or Lord of Beasts, but for this there is, again, no actual evidence. A possibility is that the central theme of Indus religion was a combined or dualistic male-female deity, symbolised by animals, trees and other forms of vegetation. Possehl suggests that some parallels found in some later Hinduism are striking,[92] possibly having been handed down over the centuries.

Late Harappan (or Post-Urban) Phase

The cause of the decline of the Indus Civilisation has provoked much discussion and debate amongst scholars. Excavations show that *c.* 1900 BC, signs of a gradual decline began to emerge, particularly in Sind and West Punjab, and by 1800 BC Mohenjo-daro had been abandoned

[88] Parpola 1994: 3, 14.
[89] Rao *et al.* 2009: 1165.
[90] *Tradition*: 364-366; *Rise of Civilisation*: 213-217; *Contemporary Perspective*: 141-155; *South Asia*: 99-110.
[91] *Further Excavations*: 335-336, plate XCIV, no. 420; National Museum, New Delhi (inv.5075/123). See *Mohenjo-daro*: 52-53, pl. XII, no. 17; and for further discussion, see *Contemporary Perspective*: 141-142.
[92] *Indus Ethnobiology*: 14.

Figure 4. Steatite seal from Mohenjo-daro depicting a likely religious scene of a deity surrounded by animals (DK5175); Mature Harappan Phase, National Museum, New Delhi (5075/123).

and Harappa reduced in size, possibly because of flooding and salination of the soil.[93] It has also been suggested that Kalibangan suffered a similar fate, but probably because of the encroachment of the desert and the drying-up of the Ghaggar-Hakra River. Also suggested as a cause is changes in the monsoon scenario, which was a major contributory factor to the eventual drying-up of the river and the consequent migration some centuries later.[94]

In some parts of the Indus Civilisation in Gujarat, Rajasthan and Haryana, there is evidence of a declining common ideology, urban population decrease, and a reduction in the number of village and urban centres, possibly because of migration from the central settlements. We now witness either migration away from these sites or a change in settlement and subsistence that leaves little archaeology, such as an expansion of pastoral nomadism. Yet at the periphery, such as Gujarat, many sites, e.g. Rojdi, continue and flourish and there is likely to even have been a population increase. At Rojdi itself, we see in this period a further rebuilding programme.

Further north and east, in the Punjab, Haryana, northern Rajasthan and western Uttar Pradesh, there were many known Mature Harappan settlements; by the opening centuries of

[93] For a general overview of the Late Harappan and the decline of the Indus Civilisation, see Kenoyer 1991a: 331-385; 1991b: 29-59; *Contemporary Perspective*: 237-245. For a reassessment of the chronology of the Late Harappan, see Deshpande and Shinde 2005: 121-135.
[94] Tripanthi *et al.* 2004: 1141-1145.

Table 4. Characteristics of the Late Harappan Phase (after *Indus Ethnobiology*: 1-20).

CHARACTERISTICS OF THE LATE HARAPPAN PHASE	
Population Centres	There was an abandonment or severe depopulation of the cities and several settlements, including Kot Diji, Balakot, Allahdino, Kalibangan, Ropar, Surkotada, Dholavira, Desalpur, and Lothal. There was a disruption of the economy. Long-distance trade was reduced and the population of a wide range of special materials, many of which seem to have been luxury items were curtailed in manufacture, such as long barrel cylinder beads, etched beads, and inscribed stamp seals.
Population Distribution	The distribution of the human population in the Indus Valley was changed significantly. Sind and Cholistan were largely abandoned by settled farmers and there was an increase in the number of settlements in the Punjab, Haryana, western Utter Pradesh, and northern Rajasthan. The inhabitants in Gujarat seem to have remained remarkably stable.
Subsistence Regime	There seems to have been a shift in the subsistence regime with a growth in the ability of the population to sustain two harvests per year and grow millet.
Material Culture	The Indus Civilisation style in architecture and material culture disappears, along with stamp seals and the Indus Script. Society witnesses a return to a 'cultural mosaic' – not unlike that found in the Early Harappan phase. However, there is a strong line of cultural continuity throughout the whole of the region occupied by the Indus Civilisation at its height in the Mature Harappan.

[Based on *Indus Ethnobiology* 2002: 1-20]

the 2nd millennium BC, at the start of the Late Harappan, they are increased to *c.* 800, albeit smaller and mostly rural. Dispersal and dilution of the centralised society are now becoming evident from the development of localised pottery styles, gradual abandonment of the use of the Indus Script, and the disappearance of many of the standard manifestations of the Middle Harappan phase (Table 4).

Some scholars have also emphasised a continuity of cultural development. By 1700 BC, Harappa has been reduced in size, and to the west of the region we see the emergence of what is called the Cemetery H period, named after the cemetery found in Area H of Harappa, an indigenous development, but the occupants having clear and unambiguous biological affinities with the earlier Mature Harappan population at the site. Cemetery H period is characterised by: (a) changed burial customs; (b) the use of reddish pottery, painted in black with animal motifs (antelopes and peacocks), sun or star motifs, with different surface treatments to the earlier period; (c) expansion of settlements into the east; (d) rice replacing cereals as the main subsistence crop; (e) the continued use of mudbrick for building; and (f) the apparent breakdown of widespread internal and external trade, with materials such as marine shells no longer used. These fragmented, regional peoples of the Late Harappan, occur at a time when the inhabitants of the large urban centres lost control of the trade networks that had helped integrate this vast region and create its wealth.[95]

[95] Glover and Ray 1994: 61-76; Weber 1999: 813.

Continuity and Decline

There is an element of continuity from the Mature Harappan, but with a change in the focus of settlement organisation, not major cultural discontinuity or migrating populations, all of which have been suggested in the past. The remains of this culture, dating from *c* 1700-1300 BC, lingered for some centuries longer in Gujarat and in the north of Maharashtra.

A possible reason for the decline of the Indus Civilisation relates to climate change, which is also signalled for the neighbouring regions of Iran and the Near East. It is generally believed that the climate of the Indus region grew significantly cooler and drier from *c.* 2000 BC, linking it to a general weakening of the monsoon at that time. The reconstruction of the Holocene climatic sequence, particularly in the Thar Desert area of Rajasthan, demonstrates a major lowering of annual rainfall *c.* 2000 BC that may have caused major decline at the end of the Mature Harappan. Current studies suggest it was not only confined to South Asia, but to the whole of the northern hemisphere, being a major global climatic change phenomenon. This is supported by studies of regional late Holocene vegetation history showing important changes in the vegetation pattern and cover, an important indicator of climate change that appeared *c.* 2000 BC. Studies on climate reconstruction also suggest similar aridity trends *c.* 2000 BC.[96]

Another crucial factor will have been the disappearance of substantial portions of the Ghaggar-Hakra river system. Any number of reasons may have been responsible, such as changes in the monsoon patterns, or even a tectonic event that may have diverted the system's sources toward the Ganges Plain, although there is complete uncertainty about the date of this event, as most settlements inside Ghaggar-Hakra riverbeds have not yet been dated. Recent geological investigation into how the courses of rivers have changed in this region is currently being undertaken to test whether climate or river reorganisation are responsible for the decline of the Indus Civilisation.[97] At Kalibangan, Robert Raikes, using hydrological evidence, has previously argued that the site was abandoned because the River Ghaggar-Hakra simply dried up. This, he believes, is supported by the radiocarbon (C_{14}) dating evidence that shows the Mature Harappan settlement at Kalibangan was abandoned *c.* 2000-1900 BC, the same time as this environmental disaster.[98] It may have been that fluctuating climatic conditions contributed to the drying up of the river.

This was perhaps the biggest blow to the Indus Civilisation, as a huge number of important settlements were originally located in the basin of this river. Good fertile arable land and ample supplies of water made the basin of River Ghaggar-Hakra most attractive and where the population could produce surplus food. After losing this important agriculture base, many of the inhabitants of the Indus Civilisation began to be scattered and migrated to other regions with more readily available pasture and arable land. A debate has been going on whether the sea level receded *c.* 2000 BC and if so by how many metres. What we do know is that several ports on the Makran coast fell into disuse as they became almost inland sites after the receding sea levels. This must have adversely affected their international trade with the Gulf and subsequently with the Near East.

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[96] Staubwasser *et al.* 2003: 1425-1429. See also recent studies of sediments in the Bay of Bengal in Rashid *et al.* 2011: 215-228.
[97] Madella and Fuller 2006: 1283-1301.
[98] Raikes 1968: 126-203.

Possehl has emphasised that the process of a gradual de-urbanisation of the Indus Civilisation is a result of a number of related circumstances, partly characterised by: (a) the gradual decline and eventual abandonment of Mohenjo-daro, starting with important public buildings such as the 'Great Bath' and the 'Granary'; (b) the concurrent abandonment of the Sind region and the highlands of Baluchistan, the homelands of the Kulli peoples; and (c) as the headwaters of the River Ghaggar-Hakra gradually shifted to the east, many settlements in the inland delta in the vicinity of Derawar Fort in Cholistan, near the major Mature Harappan site of Ganweriwala, which may have been the centre of the bread basket of the Indus Civilisation in its Mature phase, were abandoned. Enough water remained in the Indus River delta area for limited numbers of people characterised by their Painted Grey Wares to settle there some centuries later.[99]

We are reminded that as early as 2000 BC, cultural integration began to break down, with a rise in regional systems no longer held together by a single ideological or socio-economic system, associated with an increase in smaller settlements with the abandonment of many larger urban sites.[100] In the field of agriculture, a major shift towards more localised cultural units and away from urban complexes is thought to have begun towards the end of the Mature Harappan phase. In examining the reason for this decentralisation and localisation, we must assume that major changes in agriculture were an important factor in this process.[101] At the time, socio-political and environmental issues affecting inhabitants at both urban and rural sites alike, and their responses to them, were in many ways very similar. In turn, the way the agricultural strategies change, suggests that they were a result of environmental and cultural change and not its cause.

Disruptions and shifts in agricultural production played an important role in this fragmentation. It is argued that there was a decline in traditional crops which fed the large population centres, at the same time as the emergence of new agricultural techniques and crop plants that spurred the development of local, independent communities.[102] Although explanations for these disruptions in the agricultural base tend to be regional in nature, they point to widespread causes such as tectonic movement or climate change.[103] These in turn may have caused changes in river patterns, resulting in flooding and sedimentation. Crop failure would have been followed by settlement abandonment and population dislocations and disrupted trade networks; new agricultural strategies would have then produced new, localised political units.

As to its relations with the other societies that existed in the region in the 2nd millennium BC, it is believed by some that gradual migration and acculturation are methods whereby the Indo-Aryan people and language gradually spread into the northern part of South Asia after *c.* 1500 BC. The original notion of an invasion of nomadic barbarians descending on an advanced urban civilisation, as championed by Wheeler,[104] has not been tenable now for some time. In fact, some believe that there is no clear archaeological evidence of Indo-Aryan intrusions.[105]

[99] Possehl 2000: 63-74.
[100] Shaffer 1993: 53-67; Possehl 1990: 261-281.
[101] Weber 1999: 813; Jarrige 1985: 35-68; Possehl 1986: 237-256.
[102] Jarrige 1985: 35-68.
[103] Weber 1999: 815; Madella and Fuller 2006: 1283-130.
[104] *Indus Civilisation*: 131-134.
[105] Bryant 2001: 230-231 (quoting Kennedy). There remains a debate whether population groups from the Central

Some have stressed a connection with the Indus Civilisation and those who wrote the *Ṛgveda*. Vedic hymns often speak of horses, horse-drawn chariots and horse sacrifice, or *ashvamedha*, an important Vedic and proto-Hindu rite. However, the only indigenous equid native to South Asia is the wild ass, depicted in Indus iconography and evidenced by skeletal remains, an unlikely culprit. The domesticated horse is not found in South Asia until well into the 2nd millennium BC, having been introduced from Central Asia.

There seems to have been a clear overlap between the Late Harappan and post-Indus communities, with no volume of physical anthropological evidence for the arrival of new population groups. After the cessation of their international trade, the pace of the decline of the Indus Civilisation hastened. The economic decline affected the overall life-style, which is reflected in their material culture. As they also gradually lost their agricultural base in the Ghaggar-Hakra river basin, they began shifting their settlements away from the banks of the main rivers.

New areas, such as the western part of Uttar Pradesh and the pasture rich areas of Gujarat, were now preferred in the Late Harappan and witnessed a two-way acculturation with the indigenous local non-Indus peoples. Ultimately, some have ascribed the end of the Indus Civilisation, particularly the transition from the Mature to the Late Harappan phases to epidemic infectious disease. For this to be a real option there must be evidence, of which there is none. Epidemics tend to produce burial pits or cremation sites and there is no significant change in burial practices currently. Even the Mohenjo-daro skeletons, strangely disposed of as they are, do not suggest epidemic infectious disease; it is accepted they likely died of disease, but here a mosquito and a *Plasmodium* parasite are the most likely culprits.

Climate

The recent advances in the evidence for the natural environment of the Indus Civilisation allow us to survey the rise and fall of the civilisation from an entirely new perspective. A knowledge of the climate during the Mature Harappan and the succeeding phases is important if we are to understand several factors, including the behaviour of certain diseases, the movement of people, and the potential of climate to exacerbate the demise of the Indus Civilisation urban society in the Late Harappan. We are also able to understand more fully the use of spring water and flood water capture as sustainable systems and the shifts of the River Indus Delta or sea-level changes in the Arabian Sea that led to the creation of the Ranns of Gujarat and their effect on the population of the Gujarat. Recent studies have now provided a constructive working synthesis of evidence for the palaeoenvironmental setting of the Indus region for the mid to late Holocene, especially the period *c.* 4000-1000 BC and its possible connection to important cultural changes.[106]

Some believe that the Indus Civilisation flourished during a period of optimal rainfall and ended, at least in part, due to rainfall decline.[107] The more extensive climatic record for the

Asian Bactria-Margiana Archaeological Complex (BMAC) entered the Indus Valley area in small numbers during the Mature Harappan. See also Bhan 2006: 173-178. The evidence that there was no Indo-European invasion is strengthened by a recent study if the human skeletal remain, see Mushrif-Tripathy 2019: 43-52; Witzel: 44-59.

[106] Madella and Fuller 2006: 1283-1301. See also Gupta *et al.* 2006: 1082-1090. Recent work points to a confirmation that climate may have played a role in the Indus cultural transformation (Dixit *et al.* 2014: 339-342).

[107] Singh 1971: 177-189.

period recently available to us seems to contradict this.[108] To most scholars at the time, the event of higher rainfall in the mid Holocene will have played an important role in the spread of agriculture and sedentism in the region and will have promoted increased agricultural production that contributed to the emergence of a social complexity. The higher winter rainfall would have been particularly significant for the cultivation of the winter/spring crops, e.g. wheat, barley, peas, lentils, the grass pea, and linseed, which first served as the subsistence base of the Pre-Harappan village cultures of the Indus region and its western borderlands[109] and survived the Mature Harappan. In addition, this higher rainfall would have increased flood levels in the river system, allowing for more extensive cultivation when the floods receded.

These increased surpluses would have created wealth and supported trade as well as demographic expansion, both of which would have contributed to the spread of agriculture and social complexity. It is also likely that the wetter mid Holocene created more potential for the growth of pastoralism. During the 3rd millennium BC, the water buffalo was domesticated in part of the core area of the Indus Civilisation, together with some marginal areas of the wider Indus region.[110] Here it becomes evident that its introduction and use, together with cattle, some of which were primarily for secondary products, e.g. milk and cheese, as well as for agricultural traction and local transport.[111] The use of water buffalo and cattle for agricultural work also indicates a greater integration in the farming system,[112] which also could have contributed to increasing economic growth of social complexity.[113]

While higher rainfall levels of the 4th millennium BC may have promoted the more widespread adoption of cultivation and sedentary settlement, the subsequent decline in rainfall may have contributed to growing population density in certain regions. It is suggested that the increase in sites next to the Rivers Ghaggar-Hakra and Indus during the Mature Harappan, could have been in part due to a concentration of the settlements along river systems as rain-fed cultivation became more difficult. Changing cultural practices likely involving water management, even at very low scale, may also have encouraged this concentration of population along these water courses. Increasingly concentrated agricultural populations in the river valleys and more intensive methods of cultivation, which included arid tillage from at least the first half of the 3rd millennium BC,[114] will have probably contributed to greater soil erosion rates, loss of natural vegetation, and movement of wind-blown sediments during the dry summer months.[115]

Increasing aridity will have promoted further agricultural intensification, requiring mobilisation of labour and consequent landscape modification, which might be inferred from at least some of the geoarchaeological evidence. By the time of the Mature Harappan, there must have been at least some summer cultivation of non-staple crops, e.g. sesame and

[108] Shaffer and Liechtenstein 1989: 117-126.
[109] Meadow 1996: 390-412; Tengberg 1999: 3-12; *Retrospect*: 317-390; *Retrospect*: 247-363; *Indus Ethnobiology*: 175-198; Chakrabarti 2006: 115-116.
[110] *Indus Ethnobiology*: 65-94. For rainfall, see Bryson and Swain 1981: 135-145.
[111] *Indus Ethnobiology*: 397-430.
[112] *Indus Ethnobiology*: 397-430.
[113] *Indus Ethnobiology*: 397-430.
[114] Lal 1971: 1-3.
[115] *Retrospect*: 47-80.

cotton,[116] which are likely to have required some watering during these months, although they were possibly grown on a much smaller scale than the staple food plants. The evidence from Kalibangan supports this argument; however, most of the cities of the Indus Civilisation were on floodplains, so rainfall was of less importance.[117]

Of special importance, are the agricultural changes that occurred during the Mature Harappan itself and after the decline of the large urban centres in the Late Harappan. Sites of this phase provide much more widespread evidence for the cultivation of small millets and rice, which are significant as summer, monsoon-watered cereals, in contrast to the winter to spring germination of the Harappan staples, wheat and barley.[118] The evidence for the adoption of millets may begin in some areas prior to the introduction of rice into the Indus Civilisation, which was probably first cultivated at Harappa *c.* 2200 BC. It is, nevertheless, clear that from *c.* 2000 BC, smaller and more widespread Late Harappan sites show consistent evidence for these crops.[119]

If there was the 4.2 ka BP RCC (Rapid Climate Change) event from *c.* 2200 BC,[120] we might see the archaeobotanical evidence as suggesting a cultural adjustment in terms of subsistence strategies towards more drought-tolerant, rain-fed crops and increasing reliance on two cropping seasons. In fact, these were most feasibly grown on the eastern side of the Indus region, within the normal monsoon zone, which is where it shows the greatest degree of settlement continuity and growth. In addition, as these crops produce lower yields per unit area, they might have been less suitable for the support of large urban centres and their cultivation may have encouraged larger numbers of smaller communities. What is more, the established urban Indus systems presumably depended on the accumulation and social storage of grain surpluses, particularly wheat and barley. Strategic shifts by farmers to other crops may have contributed to the decline of the economic foundations of Indus Civilisation urbanism, although a change to something of smaller scale may have been more household-based. Thus, the shifts in settlements that are seen in the Late Harappan transition might be seen in part due to agricultural readjustment to altered climatic circumstances.

Based on the present evidence we cannot, however, attribute the end of the Indus Civilisation to one harsh climatic event. Archaeologically, this process is characterised by de-centralisation and the net abandonment of more of the more westerly sites, such as in Sind, and the possible proliferation of sites in the eastern part of the Indus region. While some scholars have firmly argued against a climatic cause for the end of Indus urbanism, this view persists. Shifting

[116] *Retrospect*: 317-390.
[117] Thapar 1977: 67-73.
[118] *Indus Ethnobiology*: 199-249; *Indus Ethnobiology*: 175-198.
[119] *Indus Ethnobiology*: 175-198.
[120] Schug *et.al.* 2023; Dixit *et al.* 2014: 339-342. Recent research shows that the 4.2 kiloyear event has been described as a global megadrought that transformed a number of Bronze Age societies, including the Indus Civilisation, located as it is in a sensitive transition zone with a bimodal (summer and winter) rainfall regime. It has been possible to reconstruct changes in summer and winter rainfall from trace elements and oxygen, carbon, and calcium isotopes of a speleothem found in the Dharamjali Cave, located on the southern slopes of the Himalayas. Researchers found a 230-year period of increased summer and winter drought frequency roughly between 4.2 and 3.97 kya (*c.* 2190-1950 BC), with multi-decadal aridity events centred on 4.19 (*c.* 2190 BC), 4.11 (*c.* 2100 BC), and 4.02 (*c.* 2010 BC) kya. The sub-annually resolved record puts seasonal variability on a human decision-making timescale and shows that repeated intensely dry periods spanned multiple generations. The record highlights the deficits in winter and summer rainfall during the Mature Harappan (Urban) phase of the Indus Civilisation, which prompted adaptation through flexible, self-reliant, and drought-resistant agricultural strategies (see Gieschte *et al.* 2023: 103).

agricultural strategies at a local level, which may have been encouraged by climatic change or instability, contributed to the emergence of Indus Civilisation urbanism *c.* 2600 BC and again to de-urbanisation starting in the period 2000 BC and later.

In the former, ever more intensive agriculture and control of surpluses, which buffered inter-annual shortfall, contributed to urban centralisation. In the latter, more diversified and extensive agriculture provided strategic risk-buffering for even smaller, local groups and could have contributed to social changes that ultimately resulted in the restructuring of the civilisation's urban social system. A climatic event cannot be blamed simplistically for collapse and de-urbanisation. It is important to understand that climatic dynamics, the diverse responses of different regional ecosystems, and social processes at the level of individual agricultural communities that engaged with these local environments, are now the areas that need to be further investigated.

We are reminded that climate change is a major challenge to human communities, but climate alone does not determine the fate of civil society; it exists as one variable intertwined with other political, social, historical and cultural forces.[121] Recent research has demonstrated the effect that climate change had on the population of Harappa in the Late Harappan, as urban society disintegrated and levels of interpersonal violence and the creation of new structures within that society and the prevalence of infectious diseases demonstrate.[122]

Climatic change with a dryer environment and a change of certain river courses resulted in failures in agricultural productivity and imposed serious problems for river navigation. Agriculture continues into the Late Harappan, albeit at reduced levels and with differences in raising certain crops. Additionally, human practices, e.g. deforestation, and tectonic activity, which caused both earthquakes and disruption and realignment of upstream drainage patterns, may have had significant influences on the environment.

Recent paleoclimate reconstructions from the Beas River Valley for the latter part of the Mature Harappan (2200-1900 BC), have demonstrated hydro-climatic stress due to a weakened monsoon system that may have impacted urban centres, such as Harappa, by the end of the 3rd millennium BC. We know that climate, economic and social changes contributed to the disintegration of this civilisation after 1900 BC.

Evidence has now been produced that assesses from a study of human skeletal remains, the biological consequences of climate change and the socio-economic disruption in the post-urban period at Harappa. This skeletal evidence demonstrates the prevalence of infection and that infectious disease increased at that time. Mortuary differences suggest that socially and economically marginalised communities were most vulnerable within the context of climate uncertainty at Harappa. It also offers valuable lessons about vulnerability, insecurity, and the long-term consequences of short-term strategies for coping with climate change.[123]

[121] Adger *et al.* 2009: 335-354; Brooks *et al.* 2009: 741-765; Judkins *et al.* 2008: 17-29; Costanza *et al.* 2007: 522-527.
[122] *Infection*: 16-17.
[123] *Infection*: *passim.*

Chapter Two

Health and Population

Introduction

From the very beginning of human history, diseases have been life threatening and instrumental in causing important social change. For those engaged in research into social prehistory an understanding of disease behaviour is vitally important to our reconstruction of the way people lived their lives, as the spread of disease is strongly related to social and economic factors, such as nutrition and diet, demography, settlement location, migration, urbanisation, community hygiene, occupation, ranking, religion, and status.

The evidence we have for the morbidity and mortality caused by disease, most of it skeletal, whether studied by conventional methods or by bioarchaeology, enables us to create models explaining the evolution, natural history and behaviour of the pathogens and can help establish a better overall understanding of human adaptation to them. It also gives us the opportunity to understand in a much more intimate way how the population of these societies lived, how long they lived, and from what they died. Throughout the whole of prehistory, the impact of disease and malnutrition, coupled with low acquired resistance and immunity, often appears on human skeletal remains as a lesion and an indicator of physiological stress, which, combined with the need for healing and medicine, provides a basis for human progress.

However, lesions on human skeletal remains reflect only part of the disease profile of a society and many more instances of exposure to many other diseases will have occurred. The populations of the Indus Civilisation will have suffered the acute illnesses of urban society that must have affected many, often in epidemic form, and they will have suffered the occupational diseases and injuries that were prevalent within the massive craft industries of the period.

A search of the indices of most published works on the archaeology of the Indus Civilisation, shows that many authors have overlooked the place of disease in their reconstruction of that society. They are often governed by their own experience of living amid disease-experienced populations, where almost complete immunity exists to the many diseases that would have killed the inhabitants of major urban centres such as Harappa and Mohenjo-daro. Many are also unaware of the social effects that disease has and the major consequences that ensued.

It is believed by some that human adaption to food production and pastoralism, as against hunting and gathering, combined with both advancements in technology, brought a natural and logical improvement in nutrition and overall well-being. Implicit in this interpretation of the nature of the Neolithic Revolution, for example, is the idea that humans escaped all the rigours of hunting and gathering by turning to a more sedentary, healthy, and acceptable lifestyle, with a rising standard of living.

Over 30 years ago, Kenneth Kennedy challenged this model as applied to the prehistory of South Asia, based upon his wide and detailed examination of the human skeletal remains

discovered up to that time. From his research, which looked at the Palaeolithic right through to the very end of the Bronze Age, he challenged the accepted view and successfully painted a different picture whereby a transition from hunter-gatherer to food producer, and then urban dweller, was at an extremely high biological cost, including nutritional stresses brought about by crop failures, diseases of livestock, and the interruption of the importation of food into the urban centres. Pathogens which brought new diseases were now successfully maintained by individuals living in larger population densities of both village and urban environments. From a combination of these factors, the result was an increase in mortality and morbidity and a reduction in muscular-skeletal robusticity and the size of teeth.[1] There would also have been an increase in occupational disease and trauma, brought about by new and sometimes labour-intensive, urban-based production.

Disease, Parasites and Sedentism

Diseases have always played a pervasive role in all aspects of society. Throughout human history, individuals and entire communities, large and small, have exhibited varying levels of susceptibility or immunity to infections. These can often be hereditary but are more likely to be the consequence of previous exposure to micro-organisms.[2] Disease in humans is also a reflection of a mixture of genetic inheritance, ecology, and a relationship with those plants and animals with which they share their environment. However, adjustment of human defences against disease and levels of resistance and immunity are constantly changing, and, similarly, as micro-organisms themselves undergo continual adaptation to their environments, allowing both to survive.[3]

It has been suggested that many ancient diseases have failed to survive from antiquity because of the breakdown in the symbiotic relationship between a micro-organism and its host, and, thankfully, many of the most lethal pathogenic micro-organisms are poorly adjusted to being parasitical. Some, familiar as the parasites carrying diseases well known to us today, are still in the early stages of development and adaptation to their human hosts; although, as we also know, co-existence over time does not produce mutual harmlessness.[4]

The very earliest settlements in the Indus valley, at the beginning of the 7th millennium BC, were at first scattered rather thinly; the Pre-Harappan populations lived in relatively small settlements and most would have acquired the same spectrum of parasites in childhood. These infections in this rural society would not have been a particularly heavy burden since the diseases would clearly fail to inhibit the expansion of population in the period. Within five hundred years of the domestication of the first food crops, however, the human population would have begun to grow dramatically compared to the previous communities living within the same region. Population nucleation meant that people began to live in very close proximity, often in poor conditions, so that hygiene suffered and individuals became exposed to an increasing number of disease organisms.

[1] Kennedy 1990: 61-77.
[2] Haldane 1957: 321-322; Motulsky 1960: 28-62.
[3] Black 1988: 4.
[4] Smith 1934: 87-89.

However, the change from hunting and gathering to early arable farming and pastoralism was not universally detrimental to health. With the beginning of farming, some limited stabilisation of general health would have occurred, similar to that which had existed during the earlier hunter-gatherer period, if only for a relatively short time. This eventually created an excess of survivals over deaths in the very young and a population increase ensued. The ending of a nomadic existence meant less stress on women during pregnancy, and postnatal adjustment and genetic adaptation of each population to endemic infections will have occurred, allowing for antibody formation.

Early forms of social organisation will also have created dietary and sanitary codes, many of which have survived until the present day; in some societies of the Near East these codes were adopted to avoid the risk of illness. The most familiar of these to us are the Semitic dietary prohibitions, particularly of food produced from the pig. The probable 3rd millennium BC origins of this taboo, are quite understandable, as one realises that pigs were scavengers, given to eating human faeces and refuse. If eaten without the most thorough cooking, their flesh can transfer any number of parasites to the human population, as modern encounters with trichinosis, an infection with the parasitic worm *Trichina spiralis* will testify.[5]

It was not just worms and other parasites that flourished in the favourable conditions created by new agriculture and pastoralism, we also witness the spread amongst the human population of protozoan, bacterial and viral infections, enjoying an expanded field as the human population, together with their flocks and herds, grew. But it is only when communities become large enough and where encounters with other individuals become frequent enough. and when people lived in proximity in poor, unhygienic conditions. that the infections brought about by these micro-organisms spread. Respiratory infections are commonly associated with increased sedentism and population density – a scenario unlikely to have been particularly prevalent at Harappa.

Surprisingly, very little skeletal evidence of tuberculosis, or any similar MTBC infection that leaves skeletal lesions behind, has been identified from the Harappa, but that does not necessarily mean that the disease was absent. However, the frequency of all non-specific infectious disease appears to be generally low, with only 5% of the total Harappa sample so far displaying, for example, periosteal lesions on long bones. The comparatively high level of personal, household and community hygiene in the Indus Civilisation may well have possibly limited the spread of some but not all infectious diseases.

The most common nutritional deficiencies in the 3rd millennium BC were likely to be those of calcium and certain vitamins, such as β-carotene and ascorbic acid, the last linked to anaemia by impairing red blood cell development. We are also likely to see micronutrient deficiency syndromes as these rarely occur in populations with access to a diverse range of food items, except where certain foods are culturally restricted or where methods of food preparation reduce nutrient content.

Whilst the Indus Civilisation appears to have had a sound agricultural economy, based on cereal cultivation supplemented by a variety of fruits and legumes and a broad spectrum of animal resources,[6] the high frequencies of growth arrest indicators, such as enamel hypoplasia in

[5] *Plagues*: 49-50. See also Bible, *Leviticus* xi: 7-8.
[6] Allchin and Allchin 1982: 190-191; Belcher 1991: 107-120; Kajale 1991: 155-189; Meadow 1989: 61-74; Meado 1991: 89-106.

teeth at Harappa, do suggest that episodic food shortages may have compromised the health of some individuals in urban centres. With the indicators and evidence we have for specific endemic diseases, such as malaria, for the Indus Civilisation, a population group relying on pastoralism and food production, it might be argued that their health was in some respects slightly better when compared with some other ancient societies, but they did not escape from the effects of the intensification of agriculture which can cause a general deterioration in health, and especially dentition.

Unfortunately, there are no human soft tissue remains, so it is only possible to look for the presence of specific diseases that leave diagnostic lesions on bones (e.g. tuberculosis, brucellosis, leprosy, and pyrogenic infections such as staphylococcus and salmonellosis). It is also not possible to confirm or speculate the existence of other acute diseases, such as cholera and typhoid, as they must have been present in a growing population. However, one can identify from the skeletal pathology specific metabolic diseases and conditions, dental disease, and a whole range of instances of osteoarthritis, inflammation, and other degenerative conditions of the bone and congenital disease and deformities, i.e. Paget's disease.

In some parts of the Indus Civilisation, farming will have recreated the favourable conditions for the transmission of disease parasites that prevailed in the warm, shallow water of tropical rain forests, from where many of the diseases originally emerged, in which potential human hosts would provide a more than suitable medium for disease.[7] Amongst them would have been infection by the parasitical blood fluke *Schistosoma* sp., which produces schistosomiasis, similarly the *Anopheles* mosquito that spreads malaria, one of the most prevalent diseases in the region. Cholera may also have been endemic in the Arabian Sea, where the delta of the River Indus discharges itself and causes problem at Mohenjo-daro, when the Indus floods. In urban centres, cereals and other foodstuffs would have been stored in large quantities in purpose-built granaries and would have attracted rats, many with their attendant fleas.

The early development of pastoralism brought with it additional dangers to the human population. Many of the infectious diseases of civilisation have spread to humans from the animal population. In prehistory, contacts were closest with domesticated animals and it is therefore not surprising that many of the infectious diseases common to humans are also recognisable in animals and vice versa. For example, of what we call the sporadic zoonotic diseases, smallpox is almost certainly connected with cowpox, and influenza is shared with pigs. Other zoonotic diseases were measles and mumps; while pastoralism brought to humans many different new pathogens, such as tuberculosis and brucellosis. They did not, however, appear to spread at once; some of these sporadic zoonoses transmitted from domesticated animals remained occasional and dormant until proto-urbanisation created the conditions for them to spread and sustain crowd transmission.

Because of its population size, the Indus Civilisation is one of the primary locations in the world where important and deadly infectious diseases likely first emerged, having jumped species from animals to humans, and then evolving through natural selection into the forerunners of the diseases known to us today. A great many diseases need relatively high population densities to thrive and were quite insignificant to hunter-gathering bands in early

[7] Kent 1986: 605-636.

prehistory, becoming significant only with the development of permanent settlement, farming, and subsequent population nucleation. Therefore, the earliest forms of settlement in small agricultural communities involved new risks of pathogen and parasitic invasion.

In the Mature Harappan phase, outside the major urban centres, which had little or no forms of sanitation, increased contact with animal and human excrement, that may have accumulated in proximity to living quarters, would have allowed for a variety of intestinal parasites to thrive; the inhabitants of smaller towns would, as a rule, have used structures within the towns for the disposal of human waste. The consequences of this would have been not only an increase in contagious ova, worms, and other pernicious parasites, carriers of any number of diseases, but also the occasional contamination of supplies of public drinking water, such as streams, wells and cisterns, and thus putting public health at risk. For the Indus Civilisation, as elsewhere, the possible existence of some closed rural endogamous societies will have had a profound epidemiological effect, with the various inherited diseases and disabilities that such in-breeding produces.

Nutrition

Although it is apparent that the Indus Civilisation had a diversified diet of domesticated and, in the earlier phases, hunted and foraged food, which would have been beneficial, they did consume a great deal of grain,[8] and a diet comprised heavily of carbohydrates would have had created health problems. Even with an adequate dietary intake, deficiencies can result from impaired absorption of nutrients, caused, for example, by phytate in the bran of cereal grains. Although the consumption of leavened bread minimises this problem, since yeast fermentation destroys much of the phytate, at present there is no archaeological indication of the type of bread consumed by the population of the Indus Civilisation, and, in the absence of alternative evidence, it may be assumed that an unleavened flat bread served as a dietary staple for most of the population. The extensive consumption of carbohydrates means that we cannot overlook the likely existence of diabetes.

In addition to leading to a shortage of iron, diets relying heavily on cereals can be characterised by an inadequate intake of protein, which is essential for red blood cell formation. Deficient iron intake may also occur when infants are maintained for too long on breast milk or on cow's and goat's milk before weaning, all of which are poor sources of iron compared with red meat, fish and vegetables. Although at present it is not possible, because of the absence of stable isotope analysis, to identify the precise relative proportions of animal and plant foods in the Indus Civilisation diet, or to specify the components of the diets of children, a dietary iron deficiency is, amongst others, something that cannot be eliminated.

Nutritional stress in an urban environment also has another effect, in that it seriously affects susceptibility of an individual or a whole community to disease. The need to store food surpluses, as the result of improvements in production, can create a bias towards the kind of foodstuffs which can be preserved without deterioration. Cereals, pulses, dried fruits, for example, can be stored in clay jars for up to two years and are generally high in carbohydrates, although deficient in iron, vitamin C, and calcium. Thus, despite the improvements of urban

[8] Hemphill *et al.* 1991: 170; *The Ancient Indus*: 264.

life by the Mature Harappan phase, diet may have become poorer due to a greater dependence on these forms of stored food, with a consequential increase in both infectious diseases and other conditions brought about by a diet deficient in these requirements. For example, if most of the population ate bread made from cereals, vegetables, cheese and some meat protein, then dietary deficiency states would have existed, if only sub-clinically. A full manifestation would occur only where there were other reasons for generalised ill health and in increased physiological need, for example, during pregnancy. Equally, even sub-clinical malnutrition impairs healing and the body's resistance to infection.

A further consequence of the dietary deficiencies that existed amongst those who lived in urban centres when young might have been protein-calorie malnutrition. As a result, during childhood and adolescence, growth is suppressed to conserve calories needed to maintain basic body processes.

Migration

The migration of peoples during all stages of the Indus Civilisation, even comparatively short distances directed towards its urban centres, and the economic advantage it brought, would not only have had promoted cultural and demographic effects, but also epidemiological consequences. In earlier prehistory, people would have brought with them their domesticated animals and a host of new pathogens, whether during the wholesale movements of peoples that some believe introduced agriculture into South Asia, or just a few who quickly mingled with the existing hunter-gatherer population. Later, any internal migrations that occurred, either large or small, during the Mature Harappan may also have introduced new diseases into those areas that received the migrants, which then could have had a devastating effect when let loose on the existing population, if previous contact had been minimal or non-existent.

Survivors of the recipient communities that brought with them epidemics, tend to became demoralised and lose their existing faith in inherited custom and belief, which had not prepared them for such horrors. It is believed new infections have manifested their greatest virulence amongst young adults, owing to the excessive vigour of this group's antibody reactions to the invading organism.[9] Losses to the population in the 20-year-old plus age bracket are, of course, more lethal to the economy of a society than the deaths of the very old or the very young. Any society losing a percentage of its young adults will find it difficult to maintain itself economically.

The population of newcomers often increases disproportionate to their original size, and, when combined with the introduction of new pathogens, which sometimes can cause very serious 'virgin-soil' epidemics, the native population is often decimated and replaced by the newcomers within two or three generations.[10]

The study of migration in prehistory, especially that between urban and rural communities, has always been relatively unknown. However, isotopic data from human tooth enamel associated with the Mature Harappan cemetery burials at Harappa and Farmana, have now thrown some light on individual biochemical life histories of migration. It has been pointed out that strontium and lead isotope ratios clearly show that individual isotopic shifts are

[9] *Plagues*: 71.
[10] *Plagues*: 71-72.

consistent with immigration from resource-rich hinterlands into the cities during childhood. Cemetery populations formed over hundreds of years and composed almost entirely of first-generation immigrants suggest that inhumation was the final step in a process linking certain urban Indus Civilisation communities to diverse hinterland groups. The available isotopic data suggest that efforts to classify and regulate human movement in the Indus Civilisation likely helped structure socio-economic integration across a very ethnically diverse landscape.[11] Whether this has any implications for our study of its health, remains to be seen.

Urbanisation

At the beginning of urbanism, we begin to see the effects of diet on health, e.g. the correlation between iron deficiency and cultivated cereal grains. The population would also by now have begun to struggle to adapt to a pathogen load intensified by their new proto-urban living conditions, exposure to both viral and bacterial pathogens and the prevalence of fungi and parasites.

At the start of the 3rd millennium BC, growing urban communities within the Indus Civilisation began to become more densely populated, taking them beyond the critical threshold for the spread of density dependent diseases, many of which came into existence through species jumping and natural selection, particularly as it became necessary for sizeable human populations to live in a proximity to domesticated animals, chiefly cattle, the mainstay of the economy.

By the Mature Harappan phase, these communicable diseases could be transmitted in a variety of ways, i.e. trade and other overseas contacts, including possibly pilgrimages. With trade and navigation patterns as they now existed, many of the coastal regions of the northern and western Indian Ocean and the Gulf would have begun to constitute a single disease pool, with diseases communicated through ship-borne trade, over hundreds of miles of sea,[12] through the introduction of infectious organisms from overseas. Evidence of this comes from recent research which has recorded that a number of conditions associated with urbanisation, namely extensive culture contact, climate and socio-economic changes, exacerbated the risks for the spread of infectious diseases,[13] based on prior evidence for leprosy in the human population at the peripheral settlement of Balathal *c.* 2000 BC, and molecular evidence for long-standing interaction among MTBC lineages and human populations in South Asia.[14] It was also hypothesised that there should be evidence for infectious diseases from the MTBC family in the skeletal populations from Harappa, and the results of work on the Harappa skeletons provide support for this hypothesis.[15] It is also possible to infer that the presence of leprosy in the urban-phase skeletal sample from Cemetery R-37 demonstrates that the disease was present at Harappa before the end of the Mature Harappan (Harappa 3C) and that urbanisation and cultural contact likely facilitated the spread of MTBC in Indus populations. This was when the mycobacterial pathogens migrated between southern and western Asia and Africa as part of the 3rd Millennium interaction sphere.[16]

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[11] Valentine et al. 2015: e0123103. See *Bioarchaeology*: 180, for evidence of sex-structured migration, with males from the hinterlands migrating to Harappaand structured socio-economic integration.
[12] Cockburn 1963: 87.
[13] 13 *Infection*: 6.
[14] Barnes *et al.* 2011: 842-848; Manchester 1984: 162-173.
[15] *Infection*: 9.
[16] Monot *et al.* 2005: 1040-1042; Pinhasi *et al.* 2005: 846.

It is possible to determine some idea of the population size of the major urban centres at the time. For example, Harappa and Mohenjo-daro are thought to have had populations of up to 50,000, and likely more, and smaller sites, such as Lothal, possibly 10,000 to 15,000.[17] As a consequence, bacterial and viral diseases will no longer have had any need for an intermediate zoonotic host and therefore could spread more effectively by person-to-person contact. These diseases are likely to have been measles, mumps, whooping cough, smallpox, and tuberculosis, which are all too familiar to us.[18]

In rural areas, the epidemiological distinction between town and countryside would now have become much more apparent. Food demands from the urban centres caused population pressures, resulting in the overuse of soils, grasslands and woodlands; but, in response, farming practices improved relatively slowly in comparison. This will have allowed for endemic diseases, mostly of the countryside, i.e. hookworm, tetanus, amoebiasis and other forms of dysentery, to spread to the towns. In such urban centres the circulation of diseases would have been intensified through poor hygiene in some of the population, and with occasional contaminated water supplies, plus a full array of insect-borne pathogens.

The very existence of large urban centres would also have created their own intrinsic problems. For example, a breakdown of the transportation of food from the countryside, for whatever reason, including floods, could have created famine conditions and local crop failures which would have been difficult to overcome. Accordingly, these urban centres would have depended upon each other, and the countryside, to replenish losses from famine and diseases. The countryside would largely have been healthier, as many of the urban diseases were less likely to reach these outlying farming districts. However, once these diseases in their epidemic form penetrated the countryside, they would have had a greater epidemiological consequence than they had on the urban populations, who were already exposed to them and therefore partially immune.

The growing urbanisation and increased population density of the Indus Civilisation would have been quite conducive to the rapid spread of epidemic disease and would have taken its toll on the population, weakening resistance to many other diseases. This would have been exacerbated by little or no understanding of the cause of most illnesses. This included overcrowding, some ignorance of rudimentary hygiene, poor sanitation, poor food preparation and preservation, shared cooking utensils, and some exposure to animal and human excrement. It may also have included the lack of physical isolation of the sick and the probable periodic contamination of drinking water supplies, combined with an often meagre unbalanced and seasonal diet. In some circumstances, immunity to infection would gradually have begun to disappear, so even childhood diseases would often have been fatal, and incidence of epidemic disease is likely to have been common. This was regardless of the Mature Harappan urban public health infrastructure, admittedly the existence of which would have helped ameliorate the conditions but would not remove them. However, attention to personal and community hygiene and sanitation suggests that some of the risks, particularly of gastro-intestinal parasitism, may have been minimised.[19] Another aspect of urban life was the premature incidence of degenerative joint disease, which can be associated with excessive strain, as suggestive of a lifetime of intense physical labour.

[17] Rao 1979: 151-152.
[18] Black 1975: 515-518.
[19] *Biocultural Context*: 216.

The stress of high population densities would certainly have existed in the Indus cities and towns, as indicated by systemic stress indicators, i.e. enamel hypoplasia on teeth. Regardless of flood defences and preparedness for regular monsoon flooding, extraordinary flood conditions that would have existed from time to time, particularly around and after 2000 BC, will have resulted in significant mortality and morbidity brought about by trauma, the absence of clean drinking water, the overflowing of developed sewage systems in some urban centres; the effects of subsequent outbreaks of disease, from paediatric gastroenteritis through to cholera, would have been significant, as would the destruction of food resources, homes, livelihoods, and communities.

Our knowledge of demography, health status, stature, life expectancy, and its relationship to disease, depends upon a critical understanding of the skeletal evidence available for the period. The strictly conventional view is that the average age of death was low, not much over thirty, for those who reached adulthood, and that most females died during their childbearing years, although this has now been rethought.[20] Whereas it is reasonable to conclude that urban life expectancy in the Indus Civilisation would have risen between earlier prehistory and the start of the 2nd millennium BC, it is also speculated that for males, despite some improved living conditions, it would have probably decreased. This is explained by the increase in the number of infectious diseases and the overall effect of a process of urbanisation on the population. However, for women, their average life expectancy will have remained roughly constant, with the same nutritional and obstetric factors applying throughout the whole of the period.

Previously, not much attention was paid by the very early studies of the human skeletal remains from Mature Harappan sites to human demography, sex ratios, life expectancy,

Table 5. Life expectancy at Harappa (male and female) (after Dales and Kenoyer 1989: 94-106 (contribution by Kennedy and Lovell)).

LIFE EXPECTANCY AT HARAPPA (Male and Female)		
Age Group	N =	%
Infants (<3.5 years)	2	6
Children (>3.5-12 years)	1	1
Young Adults (16-35 years)	18	53
Middle Adults (36-55 years)	11	33
Adults of uncertain age	2	6
Identifiable Males	10	
Identifiable Females	17	
Unknown	7	

[After Dales and Kenoyer 1989: 94-106 (contribution by Kennedy and Lovell)]

[20] There is one other important caution, and this concerns the establishment of skeletal ages and life expectancy. Methods of determining age (and sex) have been developed over many years using controlled sampling; see *Disease*[3]: 30-37, although, of course, any number of factors might create local variations. The age at death is important in establishing information on disease and health. For example, in a group of people all dying contemporarily with each other, then age may be a factor in considering the nature of an epidemic and its causes. The determination of age at death of sub-adult and young adult (>25 years of age) can often be straight forward, but after that age it becomes much more difficult owing to the different rates at which people age. Sex, race, and socio-economic status will also affect how fast an individual shows signs of physically growing old. Several techniques have been developed to arrive at a skeletal age (*Disease*[3]: 35-36).

fecundity and stature. However, more recent work has changed this, e.g. the excavation of human skeletal remains at Harappa in 1987-1988 produced some sex-ratio information, but as this is based on a sample of only 34 skeletons, with seven producing no characteristics in which to determine sex, the conclusions can only be tentative, but are encouraging. Out of 27 skeletons remaining, there were 10 (37%) males and 17 females (63%).[21] As regards a rough estimate of life expectancy, of the 34 skeletons it was possible to determine skeletal ages, although the caution concerning skeletal ages below is important to our interpretation of these finds (Table 5). Of course, this data may be skewed by differential burial practices for various ages and genders, although the analysis does tentatively point to the highest mortality rate being amongst young adults. The physical stature of the Indus Civilisation population, following the study of a sample of an additional 75 adult males, 92 adult females, seven young adults, and 41 infants and children from the various burials at Harappa (Tables 6 and 7).

Urban-dwelling males are also usually shorter in stature than their rural counterparts. This difference points to the urban population usually being comparatively less well nourished, leading to skeletal retardation and reduction in growth. This was likely to be due to the deficiencies in specific components of the diet, perhaps exacerbated by seasonal food

Table 6. Physical stature of the known population of Harappa (1965) (after Chatterjee and Kumar 1965: 4-5).

PHYSICAL STATURE OF THE KNOWN POPULATION OF HARAPPA		
Male Height	Variation	183.7 - 151.9 cm
	Average	167.484 cm
Female Height	Variation	163.6 - 146.3 cm
	Average	154.561 cm

[After Chatterjee and Kumar 1965: 4-5]

Table 7. Age and sex distribution of the Harappa skeletal sample (includes a skeleton excavated in 1966 and displayed in the Harappa Museum, where it was examined in 1988 (after Lovell 1997: Table 1).

Age	**Female**	**Male**	**Unknown**	**Total**
Sub-adult <21 years	0	0	8	8
Young adult 21-30 years	6	3	1	10
Middle adult 31-40 years	7	7*	0	14
Older adult >40 years	3	0	0	3
Adult >20 years			57	57
TOTAL	16	10	66	92

Includes a skeleton excavated in 1966 and displayed in the Harappa Museum, Pakistan, where it was examined in 1988 [after Lovell 1997: Table 1]

[21] Dales and Kenoyer 1989: 94-106.

shortages, the high incidence of deficiency diseases, and by the appearance of density-dependent epidemic disease.

Women

Women, especially urban women, were also vulnerable and there were clearly health disparities between men and women. An example of this is that females had a higher incidence of teeth cavities than men and more cases of enamel hypoplasia, suggesting periodic disruptions in growth in childhood and possibly a poorer diet compared with male children.[22] There may also have been differences in the preparation of food, frequencies of eating, or even differences between foods themselves, with the males being fed protein and females being given food made up of carbohydrates.

The greatest threat to women's health may have been the sheer physical exhaustion of frequent pregnancies, with the associated dangers. It is possible that prolonged lactation may also have caused nutritional draining of body resources of vitamins and other minerals, not easily replaced by the poor diet of the period. Consequently, many women will have died at the time of peak reproductive activity and the likely higher frequency of deficiency disease, premature osteoporosis, and the increased incidence of tooth loss before death occurs amongst females.

This made women less resistant to other diseases and consequently diminished their overall life expectation compared with that of men. A child being breast-fed, for example, may well have been at risk from nutritional deficiency, possibly by a generally reduced natural defence system caused by the mother, if she was also suffering from the condition. Her milk would be of poor quality and in short supply, and putting the child at further risk, as it is unable to acquire the nutrients or other substances lacking. The most dangerous period for the child would have been the weaning stage. If the new foods were of poor quality or in short supply, this would have led to nutritional stress. However, the large number of milk-producing bovines in the society probably made this unlikely.

However, the view that nutritional and other physical stress were primarily due to pregnancy, parturition and lactation is problematic, as the primary cause of the mortality of Indus Civilisation females may be rooted in several factors relating to malnutrition, commencing at an early age, thus creating a much lower resistance to disease. Behavioural factors, such as occupationally-related physical alterations, for example, squatting and femoral neck erosion, probably for food production, will have also been important factors, as may also have been physical abuse. Additional cultural strictures, e.g. food rationing during lean periods, may have also perpetuated a cycle of malnutrition stresses into a succeeding generation.

Women were well adapted to stresses in pregnancy, parturition and lactation, and parturition in adolescence was not a likely cause, due to delayed age at menarche, itself influenced by nutrition. Not all women become pregnant, not all women reach term and give birth; not all women experience difficulties during their confinement. Therefore, not all health hazards for women should be automatically ascribed to pregnancy and parturition. There are also other factors, in that poor maternal malnutrition can be a serious threat to the foetus, as it can

[22] Lukacs and Joshi 1992: 359-372.

reduce placenta size and reduce foetal nutrition itself, not to mention the possibilities of malnutrition impairing obstetric performance. Malnutrition is the main killer of women, rather than childbirth hazards or continuous pregnancies, particularly if food was not distributed fairly amongst the sexes. The mixture of the nutritional status of women, as well as their cultural and economic circumstances, would have had a huge impact on the fate of neonates.

Children

Urban life in the Indus Civilisation could have been particularly hard on children. At Harappa, for example, there was likely to have been a very much higher child mortality rate than in the rural population, as diseases such as tuberculosis, trauma, infections, and malaria must have taken their toll. Many childhood diseases, e.g. measles, chickenpox, and other viral infections, could have been fatal, particularly if there were complications, pneumonia for example.

Against a background of seasonal nutrition, poor habitation standards and disease, a high infant mortality was often a feature of the ancient world, where a combination of these factors was a severe restraint on child survival. More specifically, where there is evidence for rickets, and probably infantile scurvy or Barlow's disease, which indicate either a poor and insufficient diet lacking vitamins C and D, or, in the case of rickets, there is a suggestion of young children working long hours in urban sweatshops devoid of sunlight. Failure of lactation by nursing mothers, owing to malnutrition, will have been the cause of death of several small children.

Health and the Late Harappan Phase

The prevalence of infection and infectious disease will have varied through time at, for example, Harappa, and correlated with fluctuating levels of environmental, social and economic stress.[23] This, combined with evidence from mortuary treatment, traumatic injury and infection, indicates that the stresses of the post-urban period were accompanied by increasing levels of inter-personal violence and disease. Leprosy, for example, was present in the Late Harappan, with leprosy and tuberculosis now affecting 15.4% of the individuals buried at Cemetery H, and leprosy affected 21.7% of the Area G specimens. Combined with their previous work demonstrating that the prevalence of violence also increased through time, affecting men, women and children from Area G at an unprecedented rate of 50%, they infer aspects of identity, or behaviour which created greater vulnerability in some Indus Civilisation urban communities.[24]

Evidence from the human skeletal remains from Harappa dated to the Late Harappan (1900-1800 BC), now demonstrates the increase in conflict, interpersonal violence, and negative impacts on human health, combined with physical deterioration of conditions in the cities, eventually led to depopulation. Those who remained suffered from interpersonal violence and infection, particularly in marginalised communities who received little protection from a weak and more decentralised society.[25]

[23] *Infection*: 6-7.
[24] *Peaceful Realm?*: 144-145.
[25] *Infection*: 16-17.

Towards the end of the Mature Harappan, climatic stress due to a weakened monsoon system may well have had a major impact on urban centres. By the beginning of the Late Harappan, this impact of environmental change would have been compounded by social disruption, which, as has been pointed out, was the combination of climate, economic, and social changes. This is supported by the evidence from *c.* 115 skeletons from Harappa that demonstrates that the prevalence of infection and infectious disease increased through time, but that it was uneven among burial communities, and mortuary differences suggest that socially and economically marginalised communities were the most vulnerable. In the Late Harappan phase, population density was diminished and settlement focused largely in the core areas of the city. Declining sanitation conditions and an increasingly disorganised settlement plan indicate that disruptions to authority were systemic;[26] this will have contributed to the spread of disease and a decline in immunity.

During the whole of the course of the Indus Civilisation, urbanism and population density, and culture contact, led to new opportunities for infectious disease to spread. It has been predicted that evidence for infectious disease would be present in the skeletal remains from Harappa, but not be evenly experienced across all segments of the population.[27]

Finally, it seemed to have become part of urban life that the population bore the strains of ecological and social change in the Late Harappan phase.[28] Centuries of economic disruption and possible environmental change during the Late Harappan likely faced increased inter-personal violence, rates of infection and infectious diseases, eventually leading to their abandonment and that of the Indus Civilisation urban lifestyle.[29]

Climate change, health, disease and migration in the Late Harappan Phase

This decline must also be seen within the context of climate change that affected the Harappan heartland in the Late Harappan. The civilisation originally developed in the context of a semi-arid climate, which was pervasive in the whole of South Asia for the latter half of the Holocene. It is possible to determine variations in human epidemiological patterns in the context of past rapid climate change (RCC) events. The 4.2 ka BP RCC event (from *c.* 2200 BC) in South Asia features cooling temperatures and increased aridity that led to changing patterns of rainfall and drought. Climate data from this period points to this event lasting roughly four centuries (2200-1800 BC) of major environmental change, including disruption of the South Asian monsoon system and dust deposition. Important environmental changes in this region is one of the factors behind dramatic shifts in the structures of society. For the Indus Civilisation this is significant for the transition from the end of the Mature Harappan or Urban to the Late Harappan or Post-Urban phases. For example, during this transition, we witness the likely introduction of social inequality and disproportionate access to resources, which influenced major socio-political disruption, societal reorganisation, site location and nucleation, together all being described as a 'collapse'.

[26] *Infection*: 1-2.
[27] *Infection*: 3.
[28] *Peaceful Realm?*: 144-145.
[29] *Infection*: 1-2.

The creation of settled farming communities after 5000 BC, looser contact with other animals, high population density, and a less varied diet, created significant challenges for human communities facing rising infection rates and significant opportunities for pathogen evolution. Human skeletal remains of the first farmers demonstrate evidence of the relationship between anthropogenic ecological changes and changing disease ecology, including the emergence, evolution and global spread of malaria, plague, tuberculosis, leprosy, brucellosis, leishmaniasis, salmonella, smallpox, hepatitis B, treponemal infections, and Chagas' disease, among others. Urbanisation also contributed to infectious disease ecology for millennia. High-density human populations, poor sanitation, and crowded living conditions facilitated the spread of communicable pathogens from person to person, compounding the risks for endemic and epidemic diseases due to contaminated air, water, and soils. Deforestation and increasing contact with other species created additional opportunities for the emergence of disease and provided new disease pools for existing diseases.[30]

[30] Robbins Schug *et al.* 2023: e2209472120.

Chapter Three

Disease and Trauma

Our knowledge of specific diseases and trauma in the Indus Civilisation is restricted to what archaeology and human skeletal remains can tell us. Archaeology can provide knowledge of public health, nutrition, healing and medicine, but it is the study of human skeletal remains that provides the best evidence for the incidence and prevalence of disease within this civilisation. Putting aside much of the earlier outdated and discredited work on ethnicity, we are reminded that human skeletal remains can offer useful information on human demography as it relates to behavioural and occupational patterns within a society, health status, nutrition, and stature. These human remains, studied by conventional methods, or by using biomolecular science, can also enable us to create several models explaining the evolution of specific disease pathogens and their vectors, not necessarily immediately evident from palaeopathological studies of skeletal remains from the Indus Civilisation. This can then establish a better overall understanding of these societies and human adaptation to infectious disease, especially genetic variations.

The evidence of diseases, traumatic injury and deformity in the Indus Civilisation, currently being exclusively palaeopathological, can lead to a distortion in our understanding, which arises from the greater likelihood of the survival of healthy bones than pathological ones. There is also the much larger problem of the identification of specific pathology from skeletal material when one is attempting to determine with certainty the prevalence of disease or the frequency of a particular disease in comparison with modern pathological data. This is, again, because the palaeopathological evidence is limited to diseases which cause osseous change and forms only a proportion of the wide spectrum of ailments which may have afflicted the population.[1] Pseudopathological changes can also be produced by erosive factors in the ground or by anthropophagic animals.

Modern clinicians know of the difficulties of diagnosis on the living, never mind on skeletal remains that are 4000 years old. A significant additional problem, already recognised by most scholars in the field, concerns the clinical presentation of specific diseases, particularly viral. Some diseases may have frequently mutated in response to environmental factors over a very

[1] As well as marks or lesions on the bone as an indicator of specific or non-specific disease, there are also Harris lines, or lines of arrested growth, being radio-translucent, develop at the epiphyseal plates during the period of an individual's growth. See *Human Paleopathology*: 422-423, and the seminal paper by H.A. Harris (1931: 622-640). Such lines form non-specific evidence for disease and may be caused by nutritional deficiency (possibly due to food shortages) or periodic attacks of any number of specific and non-specific diseases. In teeth, the defective structure of tooth enamel is another sign of disease. Pits or ridges in the dental enamel are often caused by childhood illnesses such as measles, chickenpox, or scarlet fever, or can be caused by nutritional deficiency, which interrupted the development of enamel during the stage of a tooth's formation. However, the use of Harris lines as an indicator of disease stress has been questioned, as some Harris lines are known to disappear in later life. There is evidence of three cases of arrested grown lines (Harris lines) appearing on the long bones (visible through radiology) from Harappa, suggesting growth disturbance in childhood. See also Possehl 1999: 33. He stresses the need to study human skeletal remains for Harris lines and signs of rickets, and by looking at secondary dentition for enamel hypoplasia and signs of occupational use. There is a useful survey of the finds of human skeletal remains from Indus Civilisation sites in association with burial customs in Dibyopama *et al.* 2015: 1-9.

long period and today present themselves quite differently than they would have during the period in question. As diseases adapt to new hosts within changing environments over time, the symptoms themselves must inevitably change in intensity and will become modified during centuries of alternating widespread active and non-active states. One must only look at the SARS-CoV-2 virus, that has brought us COVID-19, as a case in point. Therefore, it may be impossible to identify some of the diseases that were prevalent during the period with diseases known to us today. Neither should it be forgotten that the impact of a disease can be significantly modified by long-term nutritional status of an individual. Other than by the study of enamel hypoplasia on teeth, many conditions of childhood are sometimes impossible to detect once the child becomes an adult as the re-modelling of bones will lead to an erasure of the evidence.

On the more positive side, the skeletal material also provides evidence for traumatic and other lesions,[2] stature and disturbance of growth, bone composition, dental health, and specific pathological changes.[3] Farming and other forms of intensive physical labour, together with a growth in population, may possibly begin to explain the greater frequency of pathological conditions involving the vertebral column, the diploë of the cranium, and the bones of the axial skeleton.

When the material from one site is looked at, several factors must be considered when shaping the record. What was the sampling technique? What has been the preservation process? What regional factors must be considered? Mehrgarh, for example, is the only Pre-Harappan site from that period to produce a sizeable number of skeletons that have been studied, and that any results will not necessarily apply to the population of other contemporary sites in this vast region. Equally, the human skeletal remains from the large urban settlements (Mohenjo-daro, Harappa, and elsewhere) are all from the Mature or Late Harappan phases and the same point applies. Caution on the use, survival, and study of human skeletons from the Indus Civilisation is endorsed by Possehl.[4] We also face the archaeological problems of skeletal material from burials in urban locations, such as the intramural human remains from Mohenjo-daro, which are sometimes disturbed and disarticulated owing to subsequent interments and funerary rites, and consequently it has been impossible to recover many complete skeletons for study.

Human health and nutrition are not merely associated through the quantity or sufficiency of food ingested, but many diseases, confirmed by the skeletal evidence, are also connected with the kind of food eaten, or with their animal or plant origins. The susceptibility of humans to certain forms of disease, such as infections and diseases of vitamin or mineral deficiency, may often be the result of the immune status of that individual so affected. However, they are mostly determined, as they are today, by social or cultural factors, e.g. subsistence and availability of nutrition, the quality of housing and other living conditions, and the quality of hygiene and sanitation, often related to social customs. Patterns of disease will often represent the effects of culture and economic status acting upon individuals, or, more usually, groups of individuals.

[2] Some diseases identified are only secondary to a primary affliction that distressed the individual, and may or may not have been the cause of death.
[3] Cohen 1989: 107-112.
[4] Possehl 1993: 32-35.

One reason for the decline of the Indus Civilisation may have been a deterioration in health. Studies of the human skeletons found in the upper strata at Mohenjo-daro point to many individuals suffering and dying from diseases, including malaria, which were prevalent, particularly in the major urban centres, with their abundance of both clean and contaminated water in cisterns, drains and wells. The leaking of contaminated water from drains into well water or extensive flooding may even have caused outbreaks of cholera, which can rapidly escalate into an epidemic. Regardless of these obstacles, it has been possible, through palaeopathology and the study of ancient nutrition, combined with a general understanding of pathogens and their vectors, to begin to quantify the examples of specific disease from which the Mature Harappan urban populations will have suffered. However, it must be stressed that we need considerably more samples to fully substantiate the existence of many of them and identify others whose prevalence is speculated.

Disease and trauma in the rest of this chapter is grouped into several broad categories and sub-categories, although it is accepted that there will be a degree of overlap.

Childbirth

There is little evidence for obstetric trauma, but as with any other ancient society, women would have faced any number of problems of childbirth. Whilst pregnancy and childbirth are not an illness, it has a considerable effect on the overall health of the female population, because female health is sufficiently determined by childbirth stress to show less response than male health to improved living conditions.

The skeletal material discovered to date shows only one case from Harappa of a likely obstetric condition, that of a young female (>25 years) (H88/197-194a) found with a neonate (H-88/197-94b) located under her lower left leg. It was found in a burial in the northern extension of Cemetery R-37 during the 1987-1988 excavation season. The mother and her baby probably died in childbirth for whatever reason, although it is suggested that the mother had pelvic deformities, which probably will have contributed to the fatality, caused by foetal obstruction, possibly brought on by inadequate diet, deficiency disease, or osteomalacia.[5]

In the ancient world, compared with today, some young women are likely to have been of shorter stature as the result of childhood disorders, some connected with periods of malnutrition, and vulnerable to a difficult labour. It is likely that females married quite young (if marriage as such existed) and even as much as two years after the onset of menarche they may still have still between 2-9% of pelvic growth to achieve. If pelvic bone growth is hindered by poor nutrition in childhood, this in turn will often decrease the effective size of the birth canal; extra-large foetuses will therefore be more likely to die from birth trauma and also endanger their mothers if the a-p diameter (or obstetric conjugate) drops below 10 cm and does not develop to full size.[6]

We likely see some women dying at their stage of peak reproductive activity, i.e. between the ages of 20-25 years, and that childbirth was the major cause of death in the female population; the younger the woman, the greater the danger. Younger females >18 years often have a

[5] Dales and Kenoyer 1989: 91-93, fig. 34 (194 a-b).
[6] Royston and Armstrong 1989: 79-81.

higher incidence of anaemia and preeclampsia than older women, thus contributing overall to higher obstetric morbidity.[7] The greatest threat to women's health would have been the sheer physical exhaustion of frequent, sometimes annual pregnancies, with the associated dangers and the prolonged lactation causing nutritional draining not easily replaced if there was a poor diet.

There may well have been instances of rickets (osteomalacia) in young female adults associated with nutritional stress, which in infancy could have had serious consequences for them when pregnant. Those babies who survived would then have been imperilled by the inadequacy of its mother's milk. Chronically underfed women, where they can be identified, and those who had suffered or were still suffering from rickets or osteomalacia or nutritional stress from childhood, usually produce milk deficient in calcium, thus adding to the likelihood of the child itself suffering from rickets in early infancy, while further undermining the health of the mother.

Most demographics in the ancient world show a disparity between the average life spans of men and women, and the Indus Civilisation was likely to have been no exception; women consistently dying before men. This has traditionally been attributed to the drain of pregnancy, followed by trauma (and possible complications), in parturition and the continual lactation. However, more recent work suggests that, in at least one ancient prehistoric society, women were well adapted to these stresses and that the disparity in life expectancy was more connected to their general diet, health, and subordinate place in the economy of their society.[8]

Congenital and Other Deformities

Of congenital disease,[9] other than, for example, the genetic haemolytic disease, sickle-cell disease and some instances of congenital deformity can be detected. There is such a case from Cemetery R-37 at Harappa (H87/134a) discovered in 1987, of an incidence of scaphocephaly in an adult female which presents with indicators of developmental abnormalities in the postcranial skeleton and is the earliest known example from the Indus Civilisation. Scaphocephaly is a type of cephalic disorder which occurs when there is a premature synostosis or fusion of the sagittal suture, which joins together the two parietal bones of the cranium and is the most common of the craniosynostosic conditions, characterised by a long, narrow head.[10]

Partial sacralisation of the fifth limber vertebra was observed in a male from Cemetery R-37 at Harappa, the transverse process of the fifth lumbar vertebra was fused to the sacrum on one side, but since the condition is usually asymptomatic, when identified clinically it would not likely have caused any pain or mobility impairment.[11]

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[7] Berkow and Fletcher 1987: 2123.
[8] Gray 1994: 340; Gray (as Kimberlie Anne Calnan) 1992, unpublished PhD thesis, University of Cincinnati.
[9] For an introduction, see *Disease*[3]: 44-62.
[10] Kennedy *et al.* 1993: 1-18, pls. 1-4. The individual may also have been the subject of some trauma. There is a cranial lesion that appears to have been a hypertrophic bone formation, the result of an infection or blow to the head. There is also postcranial evidence of trauma, although the skeleton is very fragmentary, Kennedy *et al.* 1993: 16-17. For a fuller description, see Lovell 2014b: 8-9.
[11] Lovell 2014b: 8-9.

Another instance of congenital disorder is to be found on a young to middle aged adult male from the Mature Harappan site of Kalibangan (Burial 26). The bones of his left hand, radius and ulna and feet show marked pathological deformities. The carpals and metacarpals are badly twisted to the left outwards and his left radius and ulna were smaller that their right-handed counterparts. The phalanges of the left foot are represented by only rudimentary bones, riding over each other. He was obviously disabled from birth.[12]

From Kalibangan comes a child's cranium suggestive of hydrocephaly, and three small holes are suggestive of cranial trepanation (see Chapter 6). A child's cranium from Lothal also appears to be suggestive of hydrocephaly and received the same treatment (See Chapter 6). Nancy Lovell reports a yet unillustrated, nor described in any detail, case of an individual from the Indus Civilisation cemetery at Sanauli, who apparently suffered from a pronounced kyphosis of the spine.[13]

One would usually expect to find examples of Paget's disease (*Osteitis deformans*) which is not a congenital but an acquired deformity. It is a chronic disorder of the adult skeleton, involving disruption of the mechanism of normal bone turnover, in which localised areas of bone became hyperactive and are replaced by a softened and enlarged osseous structure, causes remodelling of bones and deformities in old people; it attacks several bones and progresses slowly. Heredity seems to play a significant role, but the aetiology is still unknown.[14] The socket of the distal end of the humerus (where it meets the ulna) can sometimes be perforated by the epitrochlear foramen. Often this can be modified by intense manual labour and vigorous use of the elbow. Possibly suffering from Paget's Disease, both the humeri on the male Burial 8 and the left humerus from Burial 11 from Kalibangan present with this and point to some occupation that required vigorous use of the arm and the elbow. The formation of an exostosis has been observed on the proximal end of the right ulna belonging to the same male skeleton. A craggy mass of bone was observed on the upper part of the shaft. The result was a triangular outgrowth; but its cause is unknown.[15]

Infections and Infectious Diseases: an overview

Infectious disease was undoubtedly the single greatest threat to human life in antiquity, with epidemics reputed to have killed a sizeable proportion of the populations of the urban centres at various times. Infections and infectious diseases are caused by amongst others, viruses, rickettsiae, protozoa, bacteria, fungi and multi-cellular parasites or helminths, such as worms. The significance of each is affected by any number of variables, for example, parasites will have become a greater problem after the domestication of animals.[16]

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[12] Sharma 1993: 297-299; *Departed Harappans*: 52-57, 96-97.
[13] 13 *Bioarchaeology*: 178; Sharma *et al.* 2007: 176.
[14] Grmek 1989: 70.
[15] *Departed Harappans*: 93-94.
[16] *Pre-Roman Diseases*: 250. A parasitology study of 247 soil samples was conducted between 2011 and 2016 from Mature Harappan and their contemporary Subcontinent rural Chalcolithic sites, seeking evidence for soil transmitted helminth infections (STHs). These include *Trichuris trichiura*, which can produce abdominal pain, diarrhea, and rectal prolapse, and possible growth retardation in children; as well as *Ascaris lumbricoides*, the common parasitic roundworm, which can produce cough, fever, abdominal discomfort, and intestinal ulcers. No samples from the major Indus Civilisation urban centres were positive, because of their public health infrastructure, and although the positive samples came from modern sites, it can be assumed that the STHs existed in the South Asian spoil for longer than the last 5000 years, see Kim *et al.* 2018: 1-6.

In the Pre-Harappan, the advent of agriculture also would have had a significant impact upon human health. Although it would have greatly increased the amount of food that could be produced by an individual, the emphasis on a relatively few cultigens will have increased the vulnerability of recently agriculturally based societies to famine and malnutrition.[17] In turn, any consequent nutritional deficiencies will have made humans more susceptible to disease. Extended trade to Mesopotamia and the Gulf would also have enhanced the possibility of the spread of infectious agents between different parts of the Indus Civilisation and any movement of populations in its prehistory, either from the north or the east, may well have also introduced new diseases.

The development of remedies would have been stimulated by need, and practical medicine will have arisen parallel to the increase of diseases of civilisation (see Chapter 6).[18] More specifically, the efficiency of Mohenjo-daro's water supply and waste disposal system could have unwittingly contributed to the spread of water-borne diseases. Although the population would have been careful to keep fresh water separate from wastewater, using separately engineered terracotta pipes and brick-lined drains. In practice, this technology would have been inadequate to prevent occasional seepage from the wastewater pipes and consequently it could have contaminated the wells that provided the urban centre's drinking water. Throughout the Late Harappan, the Mohenjo-daro system is unlikely to have been properly maintained and as the result of the changes to the course of the Ghaggar-Hakra River the city was subject to flooding and the situation became far worse; then there would have been ideal conditions for the spread of water-borne diseases.

Zoonotic Diseases and Diseases of Agriculture

Various diseases are known to be associated with pastoralism and animal husbandry, and the expansion of agriculture to new environments and the domestication of animals brought the potential of contracting animal-borne diseases or zoonoses. One such way was through the fouling of drinking water by animal waste and untreated animal wastes being scattered on cultivated land, which maximised the potential for parasitic worms. Typhus, tuberculosis, and anthrax are likely to have been encountered at this very early stage. Increased population concentration presented the greatest risk to health as it began to increase densities above the limits imposed by some parasitic and infectious diseases. Even ploughing the soil increased the risk of acquiring fungal diseases, or mycotic infection, as well as tetanus.

From the very beginning of the Pre-Harappan, human nucleation into larger communities that followed the development of agriculture and proto-urbanism brought increased population sizes and densities and a greater likelihood of exposure to droplet-borne infectious agents, facilitating the spread of many of them. Those animal-borne viruses which require large host populations would only have become of significance with the increase in population nucleation, such as in the Mature Harappan phase, with several new diseases making their appearance. Larger communities also created health problems associated with sanitation and the contamination of food and water supplies by human detritus and the wastes of domesticated animals, with its inherent risk of causing disease, regardless of the apparent

[17] Cohen 1984: 1-11.
[18] Wells 1990: 263.

public health infrastructure for which the large urban centres such as Harappa and Mohenjo-daro are well known.

Brucellosis would certainly have existed in the Indus Valley at the time of the Indus Civilisation. An undulant fever, it is a zoonotic septicaemia infection caused in humans by bacteria of three main species of the genus *Brucella*, i.e. *B. melitensis*, whose natural host is sheep or goats; *B. abortus*, transmitted largely from cattle; and *B. suis*, transmitted from pigs. It is characterised by intermittent waves of fever that may persists for weeks, often with subsequent relapses and prolonged periods of ill health. Like the evidence for bovine tuberculosis, brucellosis is likely to have been caused by *B. abortus*. It is associated with the consumption of milk, and in general with husbandry of cattle, although goats cannot be discounted completely. It would also have been acquired by animal contact, either from the consumption of contaminated milk and milk products and, to a lesser extent, meat, or from everyday contact with animals, particularly for pastoralists. It does not, however, leave any skeletal lesions.

Tuberculosis

Tuberculosis is an infectious bacterial disease that has seriously affected humans and animals alike throughout both prehistory and later. It can affect almost any part of the human body and the pathological changes caused by a tuberculosis infection are usually determined by the type of infecting bacillus and its portal of entry.[19] The disease in the human body is not a single disease entity but is characterised by the formation of series of tubercles and caseous necrosis in the tissues affected.

The disease is caused by the bacteria *Mycobacterium bovis* and *M. tuberculosis*.[20] The pathological response to both the bovine and human bacilli is identical, but the mode of transmission is quite different for these two bacterial types. *M. bovis* (bovine or gastrointestinal tuberculosis), which can be identified in calcified lesions within the rib cage, is transmitted from animal to man through infected animal flesh or milk and milk products and, therefore, is primarily a gut disease which produces clear skeletal lesions. The inference of these strictly different bacteria and modes of transmission is that *M. bovis* infection in humans is dependent upon a reservoir of principally cattle tuberculosis and a close and continued contact between humans and their animals. Due to some similarities in pathology, some consider *M. bovis* to be a strain of *M. tuberculosis* rather than a species. More recently, however, these two bacilli, together with another specific mycobacterium, are commonly referred to as the MTBC.[21] *M. tuberculosis* (pulmonary tuberculosis) is transmitted through droplet respiratory infection and is therefore a primary lung disease, which can also produce skeletal lesions.

The Indus Civilisation evidence suggests that the diet contained a high proportion of carbohydrates, because of the pastoral nature of much of the agriculture. Consequently, there would have been a reliance on bovine husbandry for milk and other products, including meat. This would have created the conditions for the contracting of gastrointestinal tuberculosis, with a significant increase in the consumption of contaminated milk, yoghurt, butter, cheese, and, to a much lesser extent, fresh meat, unless cooked properly. Of course, gastrointestinal

[19] *Disease*[3]: 183-193.
[20] *Disease*[3]: 183-193.
[21] *Human Paleopathology*: 118-119.

tuberculosis will only have become prevalent after the domestication of animals in the Pre-Harappan, certainly by the 6th millennium BC, and it is likely to have been more common during the Mature Harappan. Greater population densities and close contact with domestic animals are all factors which theoretically could have led to the emergence of the disease as a serious health problem.[22]

The spread of *M. tuberculosis* infection in humans is dependent upon at least one case, or a series of cases of tuberculosis in a community, spread by the close association of infected and non-infected individuals. Pulmonary tuberculosis, therefore, is predominantly a disease dependent upon population density. The epidemiology of tuberculosis is different from other diseases in that it characteristically affects young adults, especially women, in populations in which it was endemic, as well as very small children. The vulnerability of women during child-rearing years to tuberculosis is a direct consequence of pregnancy-mediated depression of the body's immune system.

Pulmonary tuberculosis will also have developed and increased because of the development of larger population groups.[23] Unfortunately, whilst an overall increase in the prevalence of pulmonary tuberculosis is a possibility, it cannot be differentiated from gastrointestinal tuberculosis, which is supposed to have been the most prevalent group, although that is not to say that the pulmonary form did not exist.[24]

Tuberculosis is also known to be a biphasic disease,[25] as a primary infection can occur where a patient has not been infected before and a secondary infection can follow.[26] A secondary infection, sometimes referred to as post-primary[27] infection, can take place by one of two processes, i.e. reactivation, where bacilli already present in the body are re-released following a breakdown of surrounding scar tissue, or re-infection.[28]

One of the most reliable identifiable features of tuberculosis can often be found in deformities of the spine;[29] skeletal tuberculous lesions involve the spine more than 40% of the time. The most marked characteristic perhaps is the presence of an angular kyphosis. Spinal tuberculosis,[30] or Pott's Disease, infrequently involves more than one to four vertebrae; bone destruction as opposed to regeneration is also a prominent feature and tubercular abscesses

[22] Bovine or gastrointestinal tuberculosis probably originated in the Near East, where cattle were first domesticated in the 7th and 6th millennia BC and spread eastwards (Bokonyi 1977). Bovine tuberculosis is a disease of cattle and other mammals that can infect humans through infected meat and milk products. This form of the disease has its greatest impact upon children, who are the primary consumers of milk products and who are more susceptible to the disease. In the millennia preceding the domestication of cattle for human consumption, when they were bred for transport and their hides, bovine tuberculosis was confined mainly to the animal rather than the human host. By the 4th millennium BC in Europe and Asia, cattle had begun to be used for milking. This major shift of dietary habits, with cattle being bred for milk as well as meat, may have ushered in a new form of tuberculosis that infected humans for the first time (Zias 1991: 152-153).

[23] Manchester 1984: 162-173.

[24] There is now the possibility of differentiating pulmonary from gastrointestinal tuberculosis through the evidence of rib lesions, see Roberts *et al.* 1994: 169-182.

[25] *Human Paleopathology*: 119; *Tuberculosis*: 17.

[26] *Human Paleopathology*: 119.

[27] *Tuberculosis*: 5.

[28] *Human Paleopathology*: 120.

[29] *Human Paleopathology*: 121.

[30] *Human Paleopathology*: 135.

are common.[31] The spine is not the only region of the skeleton where tuberculosis can leave its mark. The joints of the hip and knee are also commonly affected. Tuberculosis of the joints is associated with arthritis and identical lesions on the two opposing surfaces of the joint are likely.[32] When tuberculosis is identified in the knee joint or joints it will usually have developed from synovial tuberculosis and the deforming lesions of the knee surface.[33] The disease can also be found in the ribs (associated in nearly 9% of cases of pulmonary tuberculosis), the elbow, the shoulder (uncommon but more so in children than adults), and in the skull – but this is generally rare.[34]

Tuberculosis and the Indus Civilisation

For the Indus Civilisation, urbanisation, migration, large-scale pastoral farming, extensive internal and overseas contact, and climate change all present significant social and biological challenges for human populations, particularly if these advances include the introduction of new pathogens. Both molecular and skeletal evidence suggests that MTBC lineages have also been conserved in South Asian populations for millennia.[35] A high degree of latency in MTBC infections indicates a long-term association with human communities, near the origin of urban life. Molecular biology studies also demonstrate that polymorphisms associated with resistance to members of the MTBC lineage have been conserved in South Asian populations for millennia,[36] lending support to the hypothesis that MTBC lineages have been circulating in South Asia since at least the Late Holocene, when its maintenance in human populations would have been facilitated by significant increases in Harappan population density and culture contact.[37]

There is now specific evidence of the incidence of tuberculosis from Harappa. Although limited to two individuals (H.710 and H.722) from Cemetery H, stratum 2, it is conclusive, with these individuals presenting with classical symptoms in H.710 to the vertebrae, long bones and metatarsals. Individual H.722 was more fragmentary, but also demonstrated conclusive evidence.[38]

Looking farther afield, examination of different aspects of the lifestyle and by understanding the prevalence and aetiology of the disease, we can model the risks to which the Indus Civilisation was likely to be exposed. Given the presence of tuberculosis in several neighbouring ancient societies, such as those of the Near East, at this time, a complete lack of exposure to the disease would be most unlikely, particularly because of the society's proximity to bovines. In fact, in the Near East, tuberculosis has been identified as early as the Early Bronze Age at the site of Babedh-Dhra in Jordan,[39] more contemporary with the Mature Harappan phase. Some of the earliest evidence of tuberculosis comes from the Neolithic Nuoro in Sardinia (6000-4000 BC), which has yielded a likely case of tuberculosis in the cervical spine.[40]

[31] 31 *Human Paleopathology*: 136.
[32] *Human Paleopathology*: 138.
[33] *Human Paleopathology*: 139.
[34] *Human Paleopathology*: 139-140.
[35] Barnes *et al.* 2011: 842-848; Monot *et al.* 2005: 1040-1042; Taylor *et al.* 2009: 2408-2414.
[36] Barnes *et al.* 2011: 842-848.
[37] 37 Pinhasi *et al.* 2005: 846.
[38] 38 *Infection*: 8-9, figs. 10a-e and Table 2.
[39] Ortner 1979: 589-598.
[40] Ortner 1979: 589-598.

Returning to South Asia, by the Mature Harappan at the latest, when tuberculosis was likely to have been endemic, evidence suggests that, as outside contacts and travel were increasing, the potential for tuberculosis to be transmitted to previously unexposed populations vastly increased, with the infective risks to those who conducted trade enhanced.[41] Those who travelled westwards for trade would also have enabled infections to be spread continually from port to port and consequently the potential for this then to penetrate deeper into the country would have been significant if internal travel were sufficient. Normally, warfare would pose another circumstance under which diseases such as tuberculosis could have spread; but there is little evidence of warfare from the Indus Civilisation, unlike the Near East and Egypt.

To judge the risks of contracting tuberculosis it is important to identify what animals were present. From our understanding of the pastoral agriculture of the region, stretching back to the Pre-Harappan, we have evidence for oxen, for example, as well as many other bovine forms, and there are other domesticated animals for which we also have evidence, i.e. sheep, goats and pigs, and tuberculosis is known to affect each of these.[42] Tuberculosis has long been known as a disease principally associated with the poor, particularly the urban poor, who have always been at a higher risk of contracting diseases for several reasons, including their diets which are often not balanced. Only that which can be afforded and obtained is consumed, which can lead to a severe lack of representation of vital food groups; and the urban poor often live in overpopulated areas leading to cramped living conditions and poor hygiene.

The study of diseases in prehistoric societies is often hampered by the lack of unambiguous evidence. It seems improbable that the entire population would in some ways have escaped all contact with the disease. The foreign contacts of the Indus Civilisation in all its phases were far reaching, and whatever the reasons for movement of people, be it trade of goods, people, or migration, all significantly increased the chances of infection spreading from person to person, port to port, and region to region. Once the disease had found its hosts, the level of potential for it to spread would to some degree depend upon the environmental and living conditions to which the host was subjected. The Indus climate would not in any great way have encouraged its transmission, nor would the diet render the majority entirely helpless in terms of immunity. However, for those living within urban centres, no doubt the symptoms would have been aggravated by close living conditions and limited hygiene.

Infections

Because of the absence of soft tissue remains, and that few infections can be determined from the skeletal record, there is at present little palaeopathological evidence. However, one example, from Harappa is skeleton H87/49B4, which exhibits a lesion indicative of a localised infection, secondary to a penetrating wound on their pedal phalanx.[43]

Osteomyelitis is easily detectable, except in the early stages and is a very serious infection of the bone. It occurs where there have been penetrating injuries or compound fractures and long-term tissue infection, or by vascular transmission. It can kill through sepsis or can lead to long-term disability. Chronic osteomyelitis affecting the mastoid bones can cause deafness

[41] *Tuberculosis*: 64.
[42] *Tuberculosis*: 81.
[43] Lovell 2014b: 10.

and abscesses of the brain. Of confirmed bone infections, in samples of skeletal remains excavated from Cemetery R-37 at Harappa in 1987-1988, five individuals exhibited proliferative lesions on long bone shafts that indicate chronic inflammation of the periosteum. None of these lesions were associated with features elsewhere in the skeleton that could be considered diagnostic of a specific infection. From the Harappa samples there are four cases of localised infection or inflammation, secondary to trauma.[44]

Evidence for maxillary sinus infection has been found in one individual from Cemetery R-37 at Harappa (H.804), one individual from Area G (G.I.S.15), and two from Cemetery H stratum 2 (H.344 and H.700a). Individual G.I.S.15 from Area G demonstrated evidence of a severe maxillary infection. Individual H.344 had an alveolar abscess at the left maxillary canine and third premolar. Individual H.700a lost the left maxillary canine antemortem; the ventral wall of the alveolus has been resorbed and the exposed surfaces are actively remodeling. The left sinus is exposed and the surfaces are porous, with reactive bone formation.

The most common, but not exclusive site for the direct introduction of infectious agents into the maxillary sinus after pulp chamber exposure would be if the root(s) of the permanent maxillary first premolar teeth penetrated the anterior portion of the sinus, permitting apical drainage into the sinus. Alternatively, maxillary sinus infection can occur when a periapical abscess, developing from the root apex of a posterior tooth, erodes into the sinus, destroying the intervening bone. Periapical abscesses may arise from destruction of the tooth by caries, or from exposure of the pulp chamber by heavy tooth wear. Unfortunately, the maxillary sinuses are not easily observable if the maxillae and articulating bones are intact or otherwise obscured, so infection rates may be underestimated in many samples.[45]

Tetanus

Tetanus is caused by *Clostridium tetani*, a droplet borne bacillus which is anaerobic and thrives in wounds contaminated by soil or agricultural waste that contains the spores. With the introduction of agricultural manuring, which follows from the domestication of animals, the threat was always present of a tiny wound leading to infection. In common with most other acute infectious diseases, tetanus leaves no skeletal evidence and therefore identifying its existence and its effects are purely speculative. Following the land cultivation and agricultural developments that occurred in the Indus region before 3500 BC, the practice of both arable and pastoral agriculture would have increased the potential exposure to the disease. Cultivated soil mixed with organic refuse is an ideal medium for the survival of the spores of the anaerobic bacillus. This may even have been unwittingly promoted with the re-use of human and animal excrement as fertiliser and the inland disposal of human detritus from major urban centres, possibly collected as part of their public health infrastructure. Therefore, those working on the land were particularly liable to develop tetanus, which would have been inevitably fatal.[46]

[44] *Bioarchaeology*: 172.
[45] *Infection*: 6, figs. 5a-c; *Bioarchaeology*: 172.
[46] *Disease*[3]: 16.

Leprosy (Hansen's Disease)

Leprosy or Hansen's Disease is a chronic droplet-borne infectious disease caused by the bacteria *Mycobacterium leprae* and *M. lepromatosis*. It is primarily a disease of the peripheral nerves and mucosa of the upper respiratory tract, with skin lesions the primary external symptom. It is also a progressive chronic disease, causing permanent damage to the skin, nerves, limbs, eyes, and sometimes other tissue, and is acquired by close personal contact over a lengthy period, often amongst members of the same family.[47]

There have often been arguments about the disease's antiquity, with Keith Manchester believing that the first instance of leprosy does not enter Egypt until as late as the 1st millennium BC.[48] It is thought, however, to be an earlier manifestation from the ancient world, evolving either in East Africa or South Asia during the Late Pleistocene, before spreading to the nearest and Europe.

The evidence for South Asia comes from the large settlement of Balathal, 40 km northeast of Udaipur in the Mewar Region of modern Rajasthan, on the Indus Civilisation periphery. It is a site of the Ahar-Banas people, dating to 3700-1820 BC, contemporary with both the Early

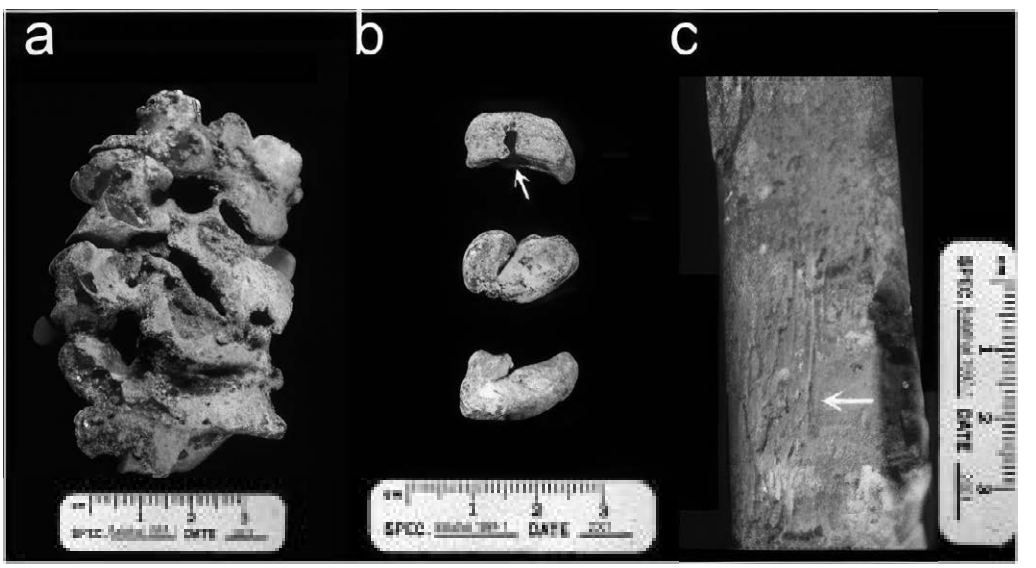

Figure 5. Skeleton from Balthal, presenting with evidence of leprosy (1997-1); Ahar Banas Culture (after Robbins *et al.* 2009).

[47] Of what is known of the response in individuals to this bacillus, the low resistance lepromatous type would have been the most prevalent (Browne 1910: 640-641). Manchester (1991: 23-35) speculates that there may have been a cross-immunity induced by the closely related disease of tuberculosis. See also *Disease*[3]:193-206. There is no single, uniform clinical presentation of this infectious disease but the different presentations, both quantitatively and qualitatively, reflect the different immune status of exposed and infected individuals (Jopling 1984). The presentations may be as diverse as the most severe, mutilating, and infectious type of lepromatous disease on one side and a relatively non-infectious type on the other (Manchester 1987: 174-176).

[48] Manchester 1992: 31-49.

and Mature Harappan phases.[49] During the excavations of 1994-1997, one burial containing one interment (1997-1) was discovered from this period.[50] This burial (Figure 5) was placed within a mound, with a stone enclosure, on the eastern end of the settlement, overlain with a somewhat earlier undisturbed layer (Layer 5) of sterile, white ashy soil, *c.* 20-30 cm thick, separating it from much later burials and settlement. This layer was deposited over 1000 years, during a period of extreme aridity in the region.[51] The monumental enclosure wall is not insignificant and might be compared to several Mature Harappan sites, such as Rojdi in the Gujarat, and when put together with the pottery found at the site, testifies to fairly close contact with the Indus Civilisation at this time. Radiocarbon dating at the site also points to the skeleton having been buried sometime between 2500 and 2000 BC.[52]

Following macroscopic study, the individual is estimated to have been a male, aged estimated at >45 years. The pathology points to antemortem tooth loss, which, when combined with other dental pathologies, probably influenced wear patterns on the surviving teeth. The state of preservation of the skeleton was poor, with only the cranium intact and the post-cranial skeleton incomplete and fragmentary.

Of major significance are the classic cranial and post-cranial lesions found on the skeleton, which strongly indicate classic signs of Hansen's Disease, demonstrated by major pathological changes in the rhinomaxillay region, including maxillary sinus infection, inflammatory response to the vertebrae, degenerative joint disease, infectious involvement of the tibia (tibial diaphysis), and injury to the peripheral skeleton.[53]

There are other possible diagnoses, which include a different treponemal infection (of various sorts), leishmaniasis, sinus and oral infection, tuberculosis, osteomyelitis, and other non-specific infections of the post-cranial bones. However, these have now been discounted and the diagnosis of leprosy confirmed.[54] The skeleton also shows evidence of a fracture to the left lunate on the articular facet of the scaphoid, possibly caused by repetitive stress injuries, perhaps a direct blow to the ulnar aspect of the wrist, or from a fall on an outstretched hand; it likely that his bones would have been weakened because of Hansen's Disease.[55]

There is also evidence from Harappa for the existence of Hansen's Disease. There are two individuals from Cemetery R-37 (H.779 and H.820), five from Area G (G.II.S.5, G.S.No.5, G.III.S.3/4, G.III.S.21 and remains labeled G.289), and two from Cemetery H stratum 2 (H.488, H.696) which present lesions consistent with a diagnosis of leprosy.[56] This indicates examples from both the Middle and Late Harappan phases.

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[49] Shinde 2000: 115-124. See also Possehl *et al.* 2004: 18-29.
[50] Robbins *et al.* 2007: 50-65.
[51] Robbins *et al.* 2009: e5669.
[52] Robbins *et al.* 2009: e5669. Samuel Mark has criticised the work of Robbins Schug and her colleagues for their current lack of biomolecular data to support the diagnosis of Hansen's Disease in the human remains from Balathal and Harappa. However, it is anticipated that biomolecular study to support their diagnosis is in hand, see Mark 2019: 375-377.
[53] Mark 2019: 375-377.
[54] Mark 2019: 375-377.
[55] Robbins *et al.* 2007: 56.
[56] *Infection*: 6-8, figs. 7a-c, 8a-b, 9a-c and Table 2. Robbins Schug has explored the express nature of the stigmatisation of sufferers of Hanson's disease in South Asia, starting at the beginning of the 2nd millennium BC, at the time of the start of the decline of the Indus Civilisation in the Late Harappan Phase (1900 BC), using skeletal evidence. For example, the two individuals from Cemetery H present with a diagnosis of Hanson's disease and she uses these

The earliest evidence for leprosy in South Asia, likely to have been before 2000 BC, or slightly later, can be used to address several hypotheses about prehistoric transmission models for the disease. Although leprosy is often considered to have a fairly recent origin, analysis of rare single nucleotide polymorphisms in contemporary samples of *M. leprae* worldwide, has identified two strains of leprosy segregating in Asia (predominantly Type I) and specifically East Africa (Type II). Because of the low frequency of the Type II strain in Asia and its high frequency in East Africa, one scenario for leprosy's origin is that Type II evolved first in East Africa (before 40,000 BC) and was later transmitted to Asia, evolving into Type I, and Europe, evolving into Type III, which is also common in West Africa and the Americas.[57] Alternatively, the Type II strain may have evolved from the Type I strain in Asia much more recently and was then transmitted out of Asia, into Africa, the Near East and Europe. Extremely small sample sizes and potentially biased demographic sampling of *M. leprae* from contemporary populations in the comparative genomics study could explain the absence of the Type II strain in South Asia. Sampling issues or fixation of the Type II strain in East Africa, combined with contemporary eradication efforts in India, may have led to an underestimate of the putative ancestral Type II strain's historical prevalence in India, and the derived Type I strain's historical prevalence in East Africa.[58]

The Late Holocene transmission scenario is more compatible with the natural history of *M. leprae*, which thrives on human contact and may have spread to East Africa during the development of urban life and large inter-continental trade networks during the Mature Harappan and its trade and cultural relationships with the Near East in the 3rd millennium BC.

If leprosy evolved in Africa in the Pleistocene, it is unlikely to have spread into Asia and become a serious health issue until the Late Holocene. It is therefore possible to argue that transmission of *M. leprae* between Asia and Africa occurred most likely in the 3rd millennium BC, when the Indus Civilisation had its extensive, wide-ranging networks for movements of peoples, goods, and potentially infectious diseases. This is also a more likely time for transmission of communicable diseases like leprosy than the Late Pleistocene migrations[59] and thus supports the interpretation of other genetic data.[60] Until the origin of leprosy is better understood, through additional research, the significance of the individuals from Balathal and Harappa is that it marks the earliest skeletal evidence to date for Hansen's Disease, demonstrating its presence in a South Asian context during a time of substantial interaction among populations throughout Asia, the Near East and Africa.[61]

examples to suggest that, amongst the Harappans, leprosy was not stigmatised and was perceived as treatable and efforts were apparently made to mitigate its impact on the journey to the afterlife; physical, social and spiritual exclusion did not emerge until much later. The method of treatment, albeit at the end of life, has not been suggested (Robbins Schug 2016: 1-9).

[57] Monot *et al.* 2005:1040-1042.

[58] Pinhasi *et al.* 2005: 846.

[59] Pinhasi *et al.* 2005: 846.

[60] Pinhasi *et al.* 2005: 846. Further research should be performed to determine the geographic origin of the disease using an integrated approach that both examines the palaeopathology and the ancient DNA, assuming that it can be obtained from individual 1997-1. Genetic comparison of the strain from Balathal and additional skeletal specimens may provide new insights into the origin of the disease if a relationship could be demonstrated with either the Type I or II strains previously identified.

[61] Robbins *et al.* 2009: e5669.

The health of the Late Harappan Phase population at Harappa, for example, sharply declined and witnessed an increase in the frequency of diseases, such as leprosy. There may also have been a hardening of social attitudes, for at Harappa, for example, we see differential treatment in burial customs between sick and healthy individuals, as those suffering from leprosy were confined to Area G of Cemetery H, beyond the city walls, suggesting that sufferers had been singled out and confined to lepers' graves.

There is no evidence of other treponemal diseases in the Indus Civilisation, such as yaws and endemic non-venereal syphilis, essentially diseases of childhood. It is also speculative as to whether any of the other sexually transmitted diseases, such as genital herpes and gonorrhoea, flourished at this time; future research may throw more light on this, but this is unlikely as they are diseases of soft tissue.

Other Diseases of Urbanisation

Population growth allowed for endemic diseases of crowded settlement to spread, e.g. anchylostomiasis (hookworm), amoebiasis, and other dysenteries.[62] By the Early Harappan, the increasing population, as shown by the archaeological evidence, now becomes large enough potentially to support epidemic disease, especially those of childhood, as an increase in the incidence of hypoplastic growth-arrest lines in tooth enamel, the result of urbanisation, indicates. The rise in the number of infant deaths may also reflect these diseases and infections, in addition to malaria.[63] The likely deaths of infants and children amongst the population as early as the Pre-Harappan may reflect the existence of diphtheria, infant diarrhoea, and diseases from poor sanitation, i.e. basilic dysentery or amoebiasis.

Because of growing urbanisation, it is likely that by the end of the Early Harappan some of the acute infectious diseases of both adults and children (measles, rubella, mumps, chickenpox, cholera, influenza) were now beginning to be known,[64] having achieved a population density large enough to maintain them. Perhaps some of the viral diseases mutated several times, but still failed to establish themselves until they encountered host populations sufficient to support them.

Some of the urn or jar burials found in cemetery R-37 at Harappa, dated to the Mature Harappan phase. contained bones of adults, children, or both. Six are said to have contained skeletal remains of infants along with adults, suggesting simultaneous deaths of children and a parent or their parents. Many children, like the adults, had been exposed before burial, but infants in this case were wrapped in cloth and buried in a jar of a special type, which is quite possibly a special burial custom associated with those who died from infectious disease.[65]

A study of the human skeletal remains from the site of Rakhigarhi points to a number of other pathologies. Other than the traumatic injury identified in BR12, two individuals, BR9 and BR02, demonstrated periosteal reactions of slight pitting with surface striation on tibias, a possible indicator of chronic infectious disease. Of these two, BR09 specifically exhibited a

[62] Angel 1975: 174. Hookworm in the gut tends also to produce severe anaemic reaction.
[63] Angel 1975: 181.
[64] Cockburn 1967: 84-107.
[65] Rao 1979: 145.

periosteal reaction on the medial surface of the midshaft portion of the right tibia, while BR02 showed the same reactions on the posteromedial surfaces on both tibiae. The femur diaphysis of BR02 also displayed evidence of osteomyelitis in the right femur.[66] The underlying disease itself has not yet been identified.

When significant diseases first invade a human adult population, with no previous exposure to them, they are likely to kill a high proportion of those infected. So, when invading virgin populations, these infections can destroy a proportion of an entire community. Diseases, persisting past the acute stage, would have been endemic at least by the end of the Early Harappan and been maintained by a smaller but growing proto-urban population; they would have included, amongst others, not only tuberculosis but diphtheria, whooping cough and scarlet fever, to which list can be added typhoid fever and amoebic dysentery. In addition, it may therefore be possible to speculate that the specific diseases also likely to be prevalent at Harappa and Mohenjo-daro were, for example, dysentery, infant diarrhoea, hookworm, and tetanus.

Smallpox

Smallpox is a profoundly serious infectious disease which has caused huge mortality and morbidity in every civilisation and period of history it has touched. Its causative agent is the strictly anthroponotic variola virus, one that can only be transmitted from human to human and has no natural reservoir and is highly contagious. Hitherto, the existence of smallpox in the 3rd and 2nd millennia BC is hotly contested, although some Egyptian evidence from the very end of the period may exist.[67]

Looking for the origins of smallpox, a central and south Asian origin is speculated. It has been proposed after a genetic study, that the camelpox virus and the variola virus are orthopoxviruses that share several biological features and cause high mortality and morbidity in their single host species. It is believed that camelpox is the closest known virus to the variola virus – the cause of smallpox.[68]

Another conjecture is that smallpox started this process of emerging and re-emerging *c.*1800-1700 BC, after diverging from a common ancestor, presumably a rodent virus, at this time.[69] This orthopoxvirus, with a wide host range in the Indus Valley, may have now acquired the ability to infect humans as a new host. This matches the period of a major decrease in the population in the Late Harappan, and, as a new lethal infection, caused massive human epidemics among the population not having immunity to this agent, thereby contributing to an already radically decreasing local population size. It has even been suggested that this was a principal cause of the Harappan decline. Presumably, the subsequent size of the human population did not allow the disease to become endemic; thus, in time this highly virulent

[66] Shinde *et al.* 2018: e0192299; Woo *et al.* 2018: 111-120.
[67] The existence of smallpox in the 2nd millennium BC is contested, but there is evidence of a skin lesion resembling smallpox in a mummy of the 20th Dynasty (1186-1069 BC) Egypt (see Nunn 1996: 77).
[68] Gubser and Smith 2002: 855-872.
[69] There is strong evidence of the black rat, the notorious *Rattus rattus*, originating in the Indus Valley region from the time of the start of early farming and that it would have spread to the Near East during the time of the expansion of tirade between the two regions in the Mature Harappan Phase (see Baig *et al.* 2018: 417-433.

human pathogen disappeared, not without leaving its mark, to re-emerge at some other time with devastating consequences.[70]

Rabies

Rabies is a viral disease, caused by lyssaviruses, that leads to inflammation of the brain in humans and which usually results in death. Its behaviour points to a very strong likelihood that the pathogens passed along the trade routes between Mesopotamia and the Indus Civilisation in the 3rd millennium BC. It is spread when an infected animal bites or scratches a human. Globally, dogs and foxes are the most common animal involved, but rodents are sometimes infected. Troels Arbøll has shown that there is some textual evidence from the *Code of Eshnunna* that rabies may have been present in Mesopotamia from 2200 BC. With active contact and trade between the Indus Civilisation and Mesopotamia at this time, it is also possible that one region may have infected the other, although the precise origin of the disease is currently unknown.[71]

Ophthalmic Diseases

Of known eye diseases, ophthalmia (trachoma and chronic glaucomatous conjunctivitis), an inflammation of the eye due to infection in childhood, *Chlamydia trachomatis*, often causes blindness, particularly after repeated infection. It is spread by contact in dirty and overcrowded living conditions, particularly by flies and practices that allow for eye-to-eye contact, and would likely to have been endemic, although no palaeopathological or archaeological evidence is to be expected. Many children in endemic areas, that will have included the Indus Civilisation, would have contracted trachoma at an early age; but hosting the disease in childhood does not provide a lifelong immunity.[72] Other medical conditions of the eye will have included trichiasis, cataracts, eye injuries, often the result of occupational injury, and various infections.

Metabolic and Nutritional Disease

From what is known of the climate and diet of the Indus Civilisation, it is likely that there existed various forms of vitamin deficiency or avitaminosis, particularly instances of vitamin A (retinol) deficiency, which causes xerophthalmia, one of whose early manifestations is night blindness; it is usually associated with a winter diet, when some vegetables were not grown. There may also have been instances of riboflavin deficiency; osteomalacia, in children called rickets (deficiency of vitamin D); and scurvy (deficiency of vitamin C); all being clearly detectable from bones[73] and usually due largely to dietary deficiencies and iron deficiency anaemia.

In the Indus Civilisation, metabolic diseases of childhood, such as rickets, causing characteristic skeletal deformities, have yet to be identified, however it has been detected from a few crania studied from the sites of Chandoli and Nevasa, located in the Indian state of Maharashtra

[70] Shchelkunov 2009: 1865-1871.
[71] Adamson 1977: 140-144. See also a study of zoonoses in Mesopotamia, in Arbøll 2021: 23-50.
[72] Karasch 1993: 897-906.
[73] Any instances of infantile scurvy may well have been the disease sprue or some other protein-losing enteropathy, which sustains malabsorption of the nutritious elements within food.

and dated to 1800-1500 BC.[74] This is very surprising as one of the main sources of vitamin D is sunlight. Vitamin D is essential in both skeletal formation and bone remodelling and therefore its deficiency leaves unmistakable markers at the gross anatomical and histological level.

If rickets existed, it must create an image of children being used for labour, perhaps in family workshops or even sweatshops, with the child rarely venturing outdoors, exacerbated by a poor diet with little calcium. The consequences are serious, leading to vulnerability and pliability of poorly mineralised skeletons and retardation of growth. Rickets is also possible in arid and semi-arid regions prone to dust storms so dense and constant that they blank out the sun for quite lengthy periods. Osteomalacia, the adult version, is mainly due to dietary calcium deficiency in later life, for which there is little evidence.

There is no evidence for adult scurvy. Infantile scurvy, or Barlow's Disease, however, develops faster in a child fed on a vitamin C deficient diet than an adult, because the adult will have vitamin C reserves stored within the body and the demands of growth in infants aids the relatively quick development of the disease. A consequence of Barlow's Disease is that an infant will have vastly increased susceptibility to infection and a reduced ability to fight it. Infants are far more at risk than adults, especially when malnutrition would have been endemic amongst young children, with pneumonia and diphtheria just two examples of the fact that infants with scurvy are more susceptible.[75] Therefore, the disease, more common amongst infants aged between five and 24 months, and reaching its peak between eight and 11 months, would likely be an important cause of child mortality where there was a dietary deficiency of vitamin C. Equally, gastrointestinal and parasitic infections cannot be ruled out as a secondary cause of the disease.

The synergistic relationship between infection and under-nutrition must also be considered. Although there are no cases of metabolic imbalance from the urban cemetery R-37, it was found that a relatively large number of infants and children were affected by abnormal porosity in combination with periosteal new bone growth in Area G (3/9) as well as in the Late Harappan Phase sample from Cemetery H. In both mortuary populations, 33.3% of the immature skeletons present had lesions interpreted as possible evidence for vitamin C deficiency or scurvy, which seems possible, considering the presence of abnormal porosity on the sphenoid, maxilla, and mandible, when in combination with evidence for subperiosteal haemorrhage in the orbits, proliferative bone on the endocranial and ectocranial surface of the cranial vault bones, including porotic hyperostosis. They suggest scurvy is more likely than anaemia, based on the absence of thickened diploë, hair-on-end appearance of the diploë, or evidence for expansion of the hematopoietic spaces.[76]

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[74] Kennedy 1990: 61-77; *Rise of Civilisation*: 271-286.

[75] Steinbock 1976: 254-256. Although scurvy is rare in the archaeological record, it can be found whereby several gross pathological changes are seen affecting the mouth, but otherwise skeletal changes are usually of a minor nature (*Disease*[3]: 171-172). A good example of infantile scurvy, or Barlow's Disease, comes from a Middle Bronze Age (*c.* 2200 BC) Syro-Palestinian site, where Mogle and Zias (1995: 77-81) have identified a case from the skeleton of an eight- to nine-year-old child, whereby pathological changes appearing in the maxilla, mandible, and orbits were highly suggestive of this metabolic disorder. The same researchers believe that scurvy was in its advanced form, which led to subperiosteal haemorrhaging, which at times turns the skin of the face and the cranium black. The child was treated by a trepanation, unusually along the sagittal suture, as a form of bloodletting in hopes of draining the subperiosteal haemorrhage in the cranium, but which, not surprisingly, led to the death of the child. For Barlow's Disease, see Clemetson 2002: 52-56.

[76] *Bioarchaeology*: 149-160.

The metabolic disorder that has been most identified in skeletal remains is anaemia. Previously, it was considered that lesions on the cranial vault, labelled porotic hyperostosis and the orbital roofs, labelled cribra orbitalia, were symptoms of chronic iron-deficiency anaemia, mostly acquired during childhood. This diagnosis of acquired anaemia has, however, been doubted. Some have proposed that porotic hyperostosis results from genetic haemolytic anaemia, such as sickle-cell disease (see this chapter) and α- and β-thalassaemia, with cribra orbitalia resulting from megaloblastic anaemia caused by dietary deficiency or malabsorption of vitamins B9 (folate, or folic acid) and B12. Others dispute that conclusion, arguing that iron-deficiency anaemia remains an arguable diagnosis for these lesions. Kennedy reports that his analysis of the total collection of skeletal remains from the Indus Civilisation, revealed that the frequency of porotic hyperostosis could be as high as 25%. Notably, 18% of the individuals from Mohenjo-daro exhibit porotic hyperostosis and there is compelling evidence for the presence of genetic anaemia in the southern reaches of the Indus Civilisation, particularly in the region of the River Indus, where Mohenjo-daro is located. Only two cases of anaemia have been reported in the remains from Cemetery R-37, excavated at Harappa in 1987, but they were very fragmentary so that no final diagnosis can be made. 28 crania were preserved in primary and debris contexts but none exhibit porotic hyperostosis or cribra orbitalia.

Environmental Disorders and Famine

The aetiology of many other illness and disorders would have been environmental. A potential toxic hazard was the extensive consumption of the grass pea or bread made from its flour, produced by milling the beans. Known in the Indus Civilisation, the chickling or grass pea *Lathyrus sativus* L., found locally today in India as *Khesari*, flourishes in conditions of the most devastating floods and droughts, when no other food crop survives. An especially hardy plant, it historically has served as an inexpensive survival food. It often appears as a stray admixture, or cultivated together with another leguminous crop, for example, the field pea, *Pisum sativum* L. and *P. arvense* L. and the horse, broad, or fava bean, *Vicia faba* L.[77] However, like the grass pea *Lathyrus sativus* L., the seeds of *V. faba* L. contain a toxic alkaloid and if not carefully boiled before eating can, if consumed regularly enough in this state, lead to a disease known as lathyrism, characterised by a spastic paralysis of the lower limbs.[78] Those affected present either subacutely or chronically with a spastic parapessis and a characteristically scissoring gait in which the balls of the feet take most of the weight. Once it has developed, neuro-Lathyrism is usually not progressive, but little or no recovery occurs, even after consumption ceases.[79] Localised aneurysms may also occur. The over-consumption of the grass pea may have been prevalent during famine, as in soups and as a vegetable supplementary protein supply.

The population of the Indus Civilisation was sustained by a high level of agricultural production, pastoralism, river and sea fishing, hunting, and the gathering of wild plants, roots and fruits. The warehouses of the large urban centres would have been used as granaries to store cereals and other foodstuffs, such as pulses and oil seeds. Their consumption of meat seems to have been dependent upon domesticated cattle and the rest of their diet was mostly soft, i.e. well-cooked and ground food, cooked in *tandoor* ovens (the use of which has survived to the

[77] Renfrew 1973: 117-118. *Khesari* has been positively identified from Harappa, Banawali, Sanghol, Hulas, Kunal and Balu.
[78] Cobley 1956: 151-153.
[79] Andrew *et al.* 1991: 450.

present day) with utensils made from copper. Famine, brought about by an interruption of the food supply by human action or natural causes, would have produced secondary amenorrhoea, oedemas, and digestive disorders of hunger. However, for the urban centres, the distributive economy should have assured at least a minimum food-supply to avoid famine, but perhaps in rural areas a prolonged drought may have been disastrous.

A study of what are likely to have been cosmetic containers from the 3rd-millennium BC site of Shahr-i Sokhta, located on the Arabian Sea, at the very eastern northern coastal edge of the Gulf, has produced evidence of cosmetic substances that have been analytically identified.[80] The study also identifies vessels found at Mohenjo-daro and Harappa that contain the substance cerussite; those found at Harappa also contained galena. Cerussite or lead carbonate, sometimes called white lead, was probably used as a white foundation for the face, and as such is very toxic, as is galena when used as eye makeup.

Neoplastic Disease

Classification of tumours of the bone are based on whether they arise in bone (primary tumours) or invade bone from another tissue (secondary or metastatic). Most of the primary bone tumours seen in human skeletons are benign and some of these benign tumours (e.g. osteomas) are well known in the skeletal record, whereas primary malignant tumours, such as osteosarcoma, are uncommon.[81] Secondary or metastatic tumours are generally less rare.[82] Whilst the overall low number of examples of neoplastic disease suggests that it is essentially a modern phenomenon, it is possible that there is an underestimation due to poorer quality palaeopathological work in the past. Of course, most tumours do not leave traces on bones.

Not surprisingly, the pathological evidence of neoplastic disease in the Indus Civilisation is again very rare and there are no skeletal or iconographical sources that allow for an identification of cancer. However, benign neoplastic growths were seen on skeletons from Harappa in the form of button ostomas on a cranial vault in two individuals and a small, elongated growth on the foot of a third skeleton.[83] However, there were no lesions consistent with primary malignant tumours which had metastasised to the cranium or foot. In fact, we really know little about the aetiology of tumours in prehistory, or about the environmental factors which led to carcinogens and which are not otherwise visible in the archaeological

[80] Massimo *et al.* 2016: 1-24.

[81] The rare appearance of malignant disease is in part due to the very nature of the evidence. Metastatic lesions themselves are of soft-tissue origin and are destructive of bone. The pathological lesion appears as an area of total or partial bone loss in the dry skeleton and may even be mistaken for post-mortem disintegration. A further reason for the rarity of the disease in antiquity may be that the common modern malignancies of the breast, lung, stomach, kidneys, and thyroid gland, disease which metastasis to bone, are mainly afflictions of the older age group in the population and that old age in antiquity was less common than today and only a small percentage of the population was susceptible to malignant disease in antiquity. Another and more straightforward reason for the palaeopathological rarity of malignant disease is that it was in antiquity, a rare occurrence. It was essentially a disease of old age. This is generally confirmed by a recent study (David *et al.* 2010: 728-732) which concentrated on the pathology of ancient Egyptian soft tissue remains and, for the first time, the first histological diagnosis of cancer.

[82] *Pre-Roman Diseases*: 257-258.

[83] *Disease*[3]: 252-263. Nancy Lovell has determined that from Cemetery R37 at Harappa two individuals exhibit benign neoplastic growths, in the form of small 'button' osteomas on the cranial vault. A third individual has a small, elongated growth on the shaft of the fourth metatarsal on the right foot. Neither malignant neoplasia of bone or cartilage, or effects of metastatic disease were identified. See Lovell 2014: 11.

record. It is likely that people failed to live long enough to develop certain forms of cancer, or to survive long enough for it to leave its mark on their bones.

During the Pre- and Early Harappan phases, changes in dietary habits may well have favoured the development of cancer through the appearance of new etiopathogenetic factors, with a new diet and/or new infectious pathologies and a new social organisation, which produced more individuals with an increased life expectancy, giving to neoplasia a richer environment in which to grow. However, carcinomas and hemopoietic tumours which occur frequently in modern populations appear to be rare in antiquity. Some malignant tumours, including nasopharyngeal carcinoma and multiple myeloma, may have occurred more frequently in the past. Regarding nasopharyngeal carcinoma, dietary factors, particularly the high consumption of vegetables containing substances likely to promote the known specific carcinogenic action of the Epstein-Barr virus (EBV), are possible. With multiple myeloma, the possibility that the high occurrence of chronic infections determined the insurgency of atypical lymphocytary clones through a continuous stimulatory action on the immune system.[84] Calvin Wells suggested that nasopharyngeal tumours sometimes seen in human skeletons are to be associated with the open fires and the smoking of foodstuffs that existed in early societies.[85]

Malaria

Of all the diseases that would have affected the Indus Civilisation and their predecessors, one of the most serious would have been malaria, often credited with providing major social and environmental consequences on any society in which it is prevalent.

Human malaria is a mosquito-borne disease caused by a parasite, but also is an active and dynamic biological cyclical entanglement of three species and two fluids. This entanglement begins and is driven by the life cycle of a species of *Plasmodium*, a single-cell parasitic protozoan that spends its entire life solely within two hosts, an *Anopheles* mosquito and a human. It continues with two fundamental biological moments involving a mosquito and two fluids, i.e. (1) when a *Plasmodium*-infected mosquito in a blood feed penetrates human skin with its proboscis and injects, alongside its saliva, sporozoites, an early developmental stage of the parasite, into the surrounding tissue; then again (2), when a non–infected mosquito in a blood feed penetrates human skin, injects saliva and with the blood ingests gametocytes, the late developmental stage of the parasite, from a *Plasmodium*-infected human. The three species meet on human skin twice: once when a mosquito infects a human with sporozoites; and then when a human infects a mosquito with gametocytes, in both instances human blood one way, mosquito saliva the other.[86]

[84] Capasso and Renato 1994: 1-51.
[85] Wells 1964: 399-400. The deposition of a carbon pigment, anthracosis, has been detected in some Egyptian mummies (Shaw 1938: 115-123). This has been attributed to a life-long exposure to open-fires, for heating and cooking. Recent advances in the technology for extracting ancient DNA have enabled the detection of a wide range of pathogen genomes, including Epstein-Barr virus in ancient human remains. The confirmation of microbial genomes deriving from human remains dating back thousands of years indicates that organisms were present in prehistory (see Arbøll and Lund Rasmussen 2023: 688-690).
[86] *Malaria*: 1-3; White 2009: 1201-1300; Warrell 1993: 191-235.

Although we cannot be completely certain, the parasite has likely existed for at least 30 million years, originating in and centred on Sub-Saharan Africa, where the fossilised remains of several genera of blood-sucking mosquitoes, including the *Anopheles*, have been found.[87] Over time, with the emergence of hominids, it eventually adapted to them, in most cases as its only host, and the *Anopheles* mosquitoes as the vector for malaria, with a subsequently long relationship between the two.

The prevalence and virulence of malaria in the Indus Civilisation was dependent on four conditions relating to the vector, the host, and the host's social and natural environment, and it is clear that malaria could only have established itself if all of these four conditions were met: (a) That malaria transmission requires a suitable anthropophilic vector susceptible to malarial infection, which feeds often and has a life span long enough for infection to develop within the mosquitoes in sufficient density for human inoculation; (b) For the mosquito to have access to an abundance of appropriate breeding places; (c) Pro-active human activity such as occupational exposure and the selection of habitation sites near mosquito breeding sites, balanced against genetic factors and eventually acquired immune resistance. Cultural and social processes such as urbanisation and the use of water resources in sanitation, unwittingly providing breeding grounds, that will promote the disease; (d) That stable climatic and geographical conditions allow the vector to continue to breed and bite. This includes rainfall, presence of appropriate water conditions for breeding, as the *Anopheles* mosquitoes prefer standing or slow-moving water, as well as optimum temperatures for the different phases of the life cycle of the parasite.

The evidence suggests that the Indus region in prehistory would have met each one of these four conditions, providing an ideal environment for the prevalence and virulence of malaria. Not only harmful to individuals, malaria can also strike whole communities in an epidemic form, as do many other acute diseases, but it is usually as a stable and endemic disease which affects communities by its slow and insidious erosion and undermining of their energy and fecundity.

In prehistory, malaria affected equally both urban and rural communities, when it eventually emerged from the tropical rainforests of Sub-Saharan Africa, the centre of its evolution, *c.* 10,000 BC.[88] The disease is first thought to have spread to the Near East by *c.* 8000-7000 BC at the earliest, when the climate became more suitable for its transmission. It is also believed that malaria would have reached the Indus Region by contact with the Near East and Iran probably *c.* 4000 BC,[89] through wind-borne dissemination or by human agency, with infected mosquitos carried on very primitive sea-going vessels. During the next 2000 years, growing trade in objects and organic and inorganic commodities, and the movement of groups of people, will have enabled the introduction of newer strains of malaria and a more efficient transmission of the disease. This would also have been initially helped by human-imposed changes to the natural environment, leading during the Early Harappan to increased mosquito populations and the *Anopheles* mosquito inhabiting more and more urban areas, thus providing ideal circumstances for malaria to flourish – with its fatal consequences.

[87] Mattingley 1973: 160-172; Mattingley 1976: 1-8; Capasso 1995: 91-102; Escalante *et al.* 1995: 616-626.
[88] Escalante *et al.* 1995: 616-626.
[89] 89 Cavalli-Sforza *et al.* 1994: 241.

Falciparum malaria

Falciparum malaria is the most virulent of the different species of human malaria and is the strain for which there is inferred evidence in the Indus Civilisation, during its Mature Harappan phase (2600-1900 BC), although its endemicity lasted in some places during the Late Harappan, which lasted in some places until the mid 2nd millennium BC. Spread by the parasite *Plasmodium falciparum*, it has been associated exclusively with humans from the time of the divergence of hominids from their closest hominoid relatives in an evolved symbiosis.[90] As today, it has always produced the highest mortality rate, although it might be misleading to suggest that infection by *Plasmodium vivax*, or any other strain, were not equally as endemic in the Indus Region at the time, but for that we currently have no clear evidence.

The incubation period for *Falciparum* malaria is shorter than for the other strains, but the fever can be more prolonged, being continuously remittent or intermittent. It can spread in the body very quickly, producing in its primary attack massive destruction of red blood cells and leading to dangerous levels of anaemia and then the enlargement of the liver and spleen, kidney failure, stupor, fits, coma, and, for many, death.[91] Many victims will display ample signs of malarial cachexia, which is a wasting disease, with its yellowing of the skin, severe spleen and liver enlargement, showing pathologically both organs severely darkened with a black pigment derived from the haemoglobin of the destroyed red blood cells, which also gave rise to its modern description of Blackwater Fever.

Children up to the age of five are particularly at risk, having acquired yet no immunity. Another particularly at-risk group are pregnant women, since their natural defence mechanisms seem to reduce during pregnancy and the disease can often cause miscarriage; in addition there is a tendency towards a weakening of any acquired immunity. Apart from the direct health risks of malaria for the mother, her unborn child can suffer considerable complications such as preterm delivery and low birth weight.[92]Those who are fortunate to survive the complications of the acute phase of *Falciparum* malaria, many will go on to enjoy a favourable prognosis and if re-infected, they will possess an antibody response due to acquired protective immunity. However, unlike most acute diseases, which last a few days or weeks and result in often life-long protection against full re-infection, naturally acquired immunity to malaria depends upon constant renewal of the antigenic stimulus over a period of many years. This form of immunity is also believed to be strain-specific to *Falciparum* malaria, developing slowly and only in response to repeated non-lethal infections.[93]

The annual cycle of *Falciparum* malaria amongst the Indus Civilisation, although it will have lasted throughout the year, with peaks in June to November and troughs in February to April,

[90] Mattingley 1973: 160-172; Mattingley 1976: 1-8; Luigi Capasso 1995: 91-102; Escalante et al. 1995: 616-626. Genetic analysis indicates that falciparum malaria evolved in Africa anywhere between 5000 and 3 million years ago, but the young age (less than 5000 years) of genetic variations that confer resistance or immunity, suggests a more recent evolution, perhaps coinciding with the origins of agriculture and the increase of the size of human populations, between 10,000-5000 years ago. This association suggests that malaria must have used the River Nile corridor, with its early agricultural pre-dynastic settlements, to leave Africa for Asia and corresponds to what is believed to be the date of the arrival of malaria in India.

[91] For complications such as severe anaemia, acidoisis and hypoglycaemia, pulmonary oedema, acute kidney injury, jaundice, and interactions with other infections, see White *et al.* 2014: 726-728.

[92] Okoko *et al.* 2003: 193-205.

[93] White 2009: 1210-1211.

would likely attack in an epidemic form around every June. This could explain why some pastoral farming communities may have practised, with knowledge based on experience, some form of transhumance, to avoid the malaria vector during summer and autumn.[94]

The evidence of the existence of *Falciparum* malaria is the occurrence of sickle-cell disease in the population, which is because it exists in a symbiotic relationship. This evidence is based on three distinct bodies: (a) the results of the macroscopic study of human skeletal remains; (b) human genetics; and (c) environmental factors.

Vivax Malaria

Early populations must have been victims of malaria and ultimately developed some resistance to it; it seems that the resistance to P. vivax developed earlier than to other human plasmodia. P. vivax can complete its sporogony cycle at a comparatively minimum lower temperature (16°C), helping it to establish stable foci of transmission in the temperate zones.

Sickle-cell Disease

The best studied of the haemoglobinopathies is Haemoglobin S (HbS), which is protective against severe malaria in the heterozygote or carrier state. In the homozygous form, HbS gives rise to sickle-cell disease, a condition that is commonly lethal. HbS is widely distributed throughout tropical Africa, parts of the Mediterranean, the Near East, and India, where the distribution of HbS is quite erratic and uneven, with high frequencies found in discrete

Table 8. Skeletal markers commonly associated with sickle-cell disease (adapted from Lovell 1998: Table 2).

SKELETAL MARKERS COMMONLY ASSOCIATED WITH SICKLE-CELL DISEASE	
Cranial Lesions	**Post-cranial Lesions**
Osteoporosis Diploic space widening Delayed pneumatisation of all but frontal s\sinuses Localised calvarial 'ballooning' Thinner inner and outer tables Coarse trabeculation in mandible	Coarse trabeculation Thinned cortices Widened medullary spaces Enlarged nutrient foramina Pelvic demineralisation and sclerosis Osteomyelitis Periostitis from leg ulcers, especially at ankles Joint necrosis Biconcave vertebrae ('step deformity') Distortion of hands and feet, especially in children Posterior calcaneal surface foramina and disruptions Articular surface lesions on metacarpals

[Adapted from Lovell 1998: 9, Table 2]

[94] Coningham and Young 2015: 297.

pockets.[95] Starting with the skeletal evidence in general, it comes from the identification of lesions in Indus Civilisation human skeletal remains consistent with sickle-cell disease. These include lesions to the joints and vertebrae, hip fractures, and cranial thickening, more commonly found in children under the age of four.[96] Skeletal alterations reflecting bone marrow hyperplasia, leading to articular surface metacarpal lesions, appear to be the most diagnostic for the disease in adults. In addition, diffuse osteoporosis has also been recorded (Table 8).[97]

The effects of sickle-cell disease typically begin around six months of age, when a number of health problems start developing, such as attacks of intense pain, anaemia, swelling in the hands and feet, liver disorders, bacterial infections and in adults and sometimes early death.[98] Chronic pain will often develop as people get older, with the average life expectancy likely to be in antiquity, in the region of twenty to thirty years at best.

Sickle-cell disease occurs when the sickle-cell gene has been inherited by an individual from both parents called a homozygote, and it is characterised by the production of an abnormal type of haemoglobin – HbS. Haemoglobin is a protein found in the red blood cells that carries oxygen around the body and gives blood its red colour. In this case, it occurs in the red blood cells when the blood is deprived of oxygen, forming crystals that distort the cells into the characteristic sickle shape. The sickle-cell trait occurs when the defective gene is inherited from only one parent, called a heterozygote, and generally resistant to *Falciparum* malaria. This is a classic example of genetic selection in response to the challenge of *Plasmodium Falciparum.*

When the red blood cells of a heterozygous individual with sickle-cell trait are invaded by the *Plasmodium* parasite, these cells adhere to the blood vessel walls, helping them to deoxygenate and also assume the sickle shape, but they are then soon after destroyed; the *Plasmodium* parasite being destroyed with them.[99] The existence of abnormal haemoglobin HbS usually causes no symptoms of sickle-cell disease and offers some protection from malaria, which accounts for the high frequency of the gene in areas prone to the disease. It is the homozygotes, the larger group, the sufferers of sickle-cell disease, who would, however, have been prone to malarial infection. It is emphasised that the existence of sickle-cell disease in any society, with the symbiotic relationship that exists between it and *Falciparum* malaria, and knowing that one cannot exist in any society without the other, points to a clear indicator of its existence.

Human Skeletal Evidence of Sickle-cell Disease

Specific human skeletal evidence for sickle-cell disease comes from the major urban site of Mohenjo-daro and one smaller site further south that helps substantiate our theories. The 42 skeletons discovered to date at Mohenjo-daro were found in various locations within buildings and along streets of the urban centre, and when first observed *in situ* none of the dead seemed to have been disposed of according to any known Indus burial custom.[100] Marshall originally reported the discovery of 21 skeletons, of which 14 (13 adults and one child) were found in

[95] Hume *et al.* 2003: 184-185.
[96] Hershkovitz *et al.* 1997: 213-226.
[97] Diggs *et al.* 1937: 249-259; Hershkovitz *et al.* 1997: 213-226; *Human Paleopathology*: 348.
[98] *Malaria:* 1-3.
[99] Linch 1994: 1047-1118.
[100] *Trauma and Disease:* 425-436.

Room 74 of House V in the HR area, Section B. Six more were found in Lane 4, located between Houses XVIII and XXXIII in the VS Area and a single example came from the appropriately named Deadman Lane of the HR Area, Section A. In all, seven were excavated from the streets but the remainder were found in an abandoned building.[101]

Ernest Mackay reported finding similar skeletons in his excavations at the site in 1928-1929, where a group of nine, similarly disposed of, were discovered in the DK Area, G Section. They were found resting against a wall which constituted the southern side of Long Lane and the south of the water-chute outside House II of Block 11. Mackay also encountered a second group of four skeletons in Block 8A on a staircase leading down into the Well Room 42 from the east and just 1 m below surface level. He also found one beneath the debris of Block 7 and another single specimen in the north-west corner of the Western Courtyard of Block 1. All together they included both adult males and females and some children;[102] some had only been superficially buried, covered with loose earth. Almost at the very beginning of his excavations at the site in 1965, George Dales unearthed five skeletons – three adult males, one adult female and one child – between walls of the Late Harappan phase and in an accumulation of fallen bricks, ash, and scattered pottery sherds, again similarly disposed of as found by Marshall and Mackay.[103]

Marshall attributed this phenomenon to them being the victims of plague, famine, or some other disaster from which they died, although the debate that eventually ensued concluded quite wrongly that they all were the result of a massacre by invaders at the end of the life of this urban centre. We are, of course, reminded that the date of the deposition of these skeletons varied chronologically, some to the end of Mature Harappan, others to the Late Harappan, and some of uncertain date, although all would have come from a period of decline, when by this time, the uppermost levels of Mohenjo-daro contained rather squalid and makeshift dwellings and where there occurred an intermingling of both residential and industrial activity with the former lanes and courtyards now filled with rubbish, and some buildings in-filled and with squatter houses on top. Those skeletons may well have been individuals from this shanty town, cursorily buried for whatever reason and abandoned.

All these skeletons were studied by Kennedy (in 1964, 1977 and 1980),[104] who found that only two had suffered any externally caused trauma. P.C. Dutta, in his 1969 study of parietal thinning on skeletons at Mohenjo-daro, reported varying degrees of cranial lesions in eight of them, which appeared consistently on the parietal and frontal bones of the crania, and on the maxilla (*c.* 30%), a lesion typically seen with sickle-cell disease.[105] Kennedy endorsed these observations and concluded that this evidence supports the existence of homozygotes with sickle-cell disease amongst the Mohenjo-daro population and that it seems to have been a much broader health problem amongst the population of the Indus Civilisation, as *c.* 25% of all skeletons studied showed evidence of the tell-tale cranial lesions. Kennedy was confident in associating lesion frequency in the Mohenjo-daro human skeletal remains with genetic haemoglobinopathies, with particularly sickle-cell disease being the more likely condition

[101] *Mohenjo-daro*, vol. 1: 79-81, 107-108, 184-186, 222-223.
[102] *Further Excavation*: 116-118.
[103] Dales 1965: 2.
[104] *Trauma and Disease*: 425-436.
[105] Dutta 1969: 55.

from which they suffered.[106] As for the unusual treatment of the dead at Mohenjo-daro, one is left with a picture of their speedy disposal. Some had probably succumbed to an epidemic, possibly of *Falciparum* malaria, and this may be seen as supporting the theory of these individuals having died from disease, singly or in groups, in long-abandoned buildings and streets where it was presumably thought safe to do so.

Outside the Indus Region in other contemporary societies of South Asia, the skeleton of a young adult from the Baghai Khor microlithic rock shelter in the state of Uttar Pradesh, excavated in 1967 to 1969, contemporary with the end of the Early Harappan (*c.* 2800 BC), presents with lesions on the frontal and parietal bones, indicating sickle-cell disease. The date of this site is consistent with an introduction of malaria into South India at least by then, but more likely 1000 years earlier.

Lovell believes that the lesions observed in the skeletal remains from Mohenjo-daro are more consistent with a diagnosis of acquired iron-deficiency anaemia.[107] However, she has also pointed out that many earlier excavations retained only skulls and no post-cranial remains; therefore her views should be considered inconclusive.[108] The more recent work of Kennedy, however, makes it clear that there is compelling evidence for the presence of sickle-cell disease in the region of Mohenjo-daro. Given the serious health consequences of this disease, it would normally have been eliminated from human gene pools by natural selection were it not for the survival advantages conferred by heterozygosity in endemic malaria regions.

Genetic Evidence

There is genetic evidence for the existence of sickle-cell disease in South Asia, although globally it largely affects people of African descent. The traditional model is that, like *Falciparum* malaria, the HbS mutation spread in early antiquity from its original foci, probably in West Africa, along the trading routes of the Mesopotamia[109] into South Asia by *c.* 4000 BC, confirming evidence of the prevalence of sickle-cell disease in South Asia in prehistory.[110] Additionally, an independent South Asian origin of the sickle-cell β^S-haplotype has been proposed,[111] as the DNA structure differs from that in people of African descent, suggesting that this is an independent occurrence of the disease. It has been proposed that the Indus Civilisation harboured the sickle-cell gene and caused its appearance in other societies with which it was in contact.[112] Called the Asian or Arab-Indian haplotype, it is found in India and parts of the Arabian Peninsula. This goes against the view that it was spread by Islamic expansion towards the end of the 1st millennium AD (Figure 6).

[106] *Trauma and Disease*: 425-436.
[107] Luckas and Walimbe 1986: 17-20.
[108] Lovell 1997: 115-123.
[109] For textual evidence of malaria in Mesopotamia, see Adamson 1979: 3-4; Scurlock and Andersen 2005: 36-37, 292 n.165, 440-441; Stol 2007: 15-17.
[110] *Trauma and Disease*: 425-436; Lovell 1998: 205-219.
[111] Kulozik *et al.* 1986: 239-244.
[112] Labie *et al. 1989*: 479-491; Jastaniah 2011: 289-293.

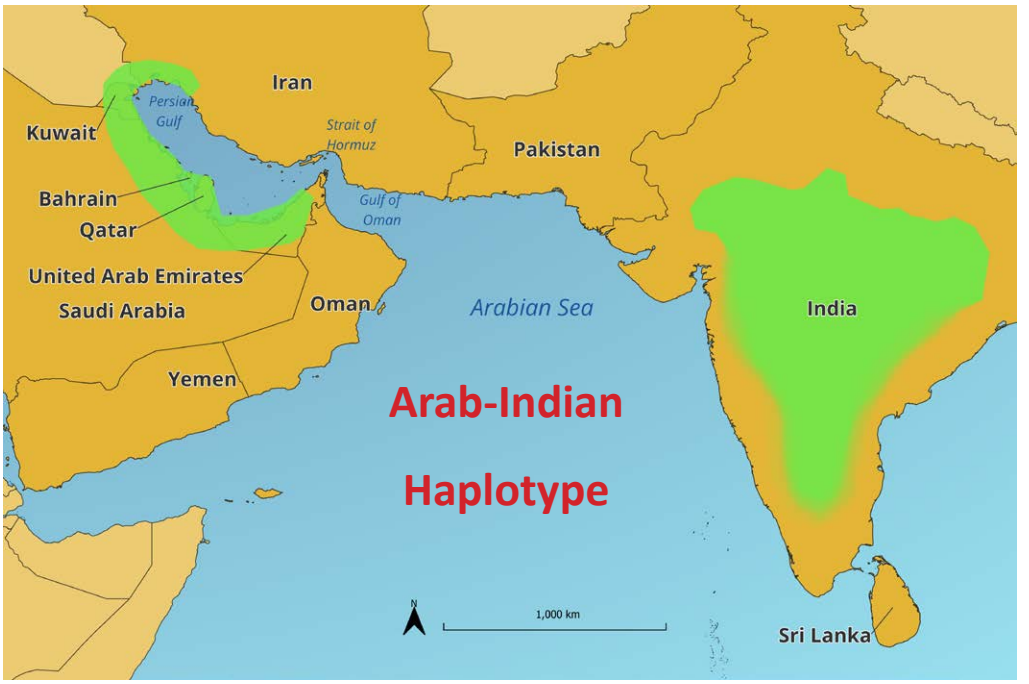

Figure 6. Sickle haemoglobin haplotype distribution in the Middle East and India.

Through its early introduction, today the disease has a relatively high core prevalence in India, with a growing mortality and morbidity rate, especially in infants and neonates.[113] It attains a frequency of 5%-10% in the central part of the Deccan Plateau, rising to 15%-20% in the far south in the state of Tamil Nadu. In the north-west, the former Indus Civilisation heartland, incidence of the disease ranges from 5%-20% of the population in areas affected by malaria, as heterozygotes largely survive malaria epidemics when many of the other non-protected inhabitants succumb, being typical of such evolutionary trade-offs, where gains and losses are so finely balanced.

The Anopheles Culcifacies Mosquito

The specific mosquito vector responsible for malaria transmission in the Indus Region in prehistory is unknown but is speculated that it may have been the *Anopheles culcifacies*, a mosquito that feeds primarily on cattle, but when it cannot feed on a blood meal and infect with the *Plasmodium* parasite, it will feed on and infect humans if they co-exist near or if cattle are unavailable, a good scenario for the Indus Civilisation.

The *Anopheles culcifacies* mosquito usually prefers a rural habitat but can adapt to urban conditions where humans are the only source for the female mosquito to feed, and can fly up to 5-6 km a night, sometimes at a speed of up to 5 km per hour, invading habitations and laying eggs in wells, drains, and ponds (Figure 7).

[113] See Balgir 2007 for a more complete discussion of the issues involved.

Figure 7. The female mosquito *Anopheles Culcifacies*.

Malaria and Climate

Some of the main factors leading to endemic or stable malaria are the number of human hosts, the daily survival of the vectors, and the duration of the transmission seasons; the latter two being heavily or entirely influenced by climate, informing our understanding of the transmission of malaria into the Indus Civilisation in antiquity and for its prevalence thereafter. The malaria parasite, *Plasmodium*, and its various *Anopheles* hosts are extremely sensitive to temperature and humidity. Even very small climate fluctuations can affect the prevalence of malaria transmission significantly, by altering geographical distribution, seasonality, and feeding and breeding patterns of both mosquito and the parasite. For example, temperature tolerances vary amongst the *Anopheles* sub-species; temperatures over 40˚C can be lethal to most species, while the lowest survivable temperature is more variable. Hibernation does afford some protection against the winter months and some species can even tolerate extreme cold.

Research shows that in regions with varied seasonal temperatures, such as in the heartland of the Indus Civilisation, mosquitoes are not active all year around because winter temperatures are too low. However, infections with the *Plasmodium Falciparum* parasites can persist beyond the malaria season if the conditions are right. These conclusions are important for understanding the persistence of *Falciparum* malaria in prehistory, especially in a seasonal environment. In many parts of South Asia, including in the north west, unusually heavy rainfall in March, April or May relates to a sharp, short rise in malaria four to six weeks later, sometimes caused by hibernating malaria-infected *Anopheles* mosquitoes returning to the open and taking advantage of water to oviposit. In the Indus region, it is usually June.[114]

[114] For a review of malaria in modern South Asia, and particularly the effect of climate and the Indus and Ganges river

This understanding of the role of climate and the environment is also important in determining the patterns of malaria when applied to the whole of the Harappan heartland. In this region, humans and bovines can be the primary food source of the *Anopheles* mosquito in both urban and rural areas, where climate and environment provide an abundance of pools of water, such as river-beds, ditches, village tanks and ponds, and irrigation canals in which to breed.[115] The geography of the city of Mohenjo-daro, due to widespread flooding and the extent of the surrounding alluvium, and that it was built on massive platforms, suggest that flooding was indeed pronounced. In combination, all these factors suggest that the environment of the area around Mohenjo-daro may have been very favourable to malaria.

Mohenjo-daro now lies in a semi-arid climate and the agricultural cycle traditionally depends on the annual inundations of the River Indus during summer, resulting from the melting of glacier ice in the Himalayas and the monsoon rains. Although the antiquity of these flooding patterns is not precisely known, what we do know is that much of the Indus Region must have been significantly wetter immediately before and during the time of the Indus Civilisation, probably due to increased winter precipitation and therefore a more suitable habitat for the mosquitoes. After *c.* 2000 BC, global paleoclimatic data indicate a change to severe arid drought conditions, which has been linked to widespread destruction and urban abandonment in the Indus region and in areas of the Near East, Egypt, Anatolia, the Eastern Mediterranean, and China.[116]

By the Late Harappan (1800-1700 BC), these climatic conditions and malarial transmission patterns would have changed. The prolonged nature of the drought would undoubtedly have restricted the number and density of some of the malaria vectors, while the more resilient and drought-tolerant species may have continued to reproduce in much smaller expanses of water. Overall, mosquito population levels would have become lower, with malaria infection rates declining consequently. Depopulation and changes to the infrastructure of the Indus Civilisation brought on by a period of decline in the Late Harappan would have resulted in a decrease in the prevalence of malaria, as the result of the reduction in the sanitary and water supply infrastructure and leading to fewer breeding opportunities.[117]

Effects of Malaria

Malaria, particularly *Falciparum* malaria, is a major debilitating disease, prone to relapsing and annual epidemics, and can very often disrupt the whole structure of society. In some ancient cultures it is possible to see malaria as a social depressant, inhibiting creativity and regular activities. The consequences of this would have been dire; for example, if a proportion of a rural community was suffering from an epidemic of malaria for a few months in the autumn when crops needed harvesting, sustained food production could have been difficult to achieve.

systems, with historical references, see Whitcombe 2012: 2216-2239.

[115] The creation of ponds of water after river flooding may have helped form breeding places for malaria-bearing mosquitoes, and endemic malaria may have followed from the commencement of sedentary subsistence technologies in South Asia. *Trauma and Disease*: 425-436; Kennedy 1982: 289-295. For recent evidence of irrigation, see Casana and Wright 2023.

[116] Shaowu 2005: 908-914; Wiener 2016: 1-16.

[117] For the Late Harappan Phase and a view of the eclipse of urbanisation, regionalisation, and the paradigm shift in our understanding of this in the last twenty years, see *Transformation*: 425-471 and Ratnagar 2002.

In its most virulent form, malaria would have exerted a considerable social effect upon both fecundity and on the energy and survival potential, particularly of small children, which would, in turn, likely lead to the creation of a selective microevolutionary process. Some survivors of *Falciparum* malaria, both adults and children, might even have suffered long-term cognitive retardation. Adults with sufficient immunity to suppress many of malaria's symptoms will still have harboured the parasite in their blood, to be transferred by mosquitoes to non-immune children who would develop acute, severe disease. As we have already seen, children under five probably bore much of the symptomatic burden evident in the population, as they do today. In areas where *Falciparum* malaria was endemic, its high mortality rate may also have had a serious demographic effect. After the age of five, infected children would gradually move into the same status as adults, with the possibility of achieving sufficient immunity to suppress the acute symptoms following most episodes of re-infection.

Humans exposed to repeated infection could develop immunity capable of restricting both clinical illness and parasite blood density. However, episodes of, for example, malnutrition can produce transient partial immunosuppression, allowing exacerbation of malarial symptoms of sufficient severity to convert a reversible infection into a lethal one. The constant presence of a malarial parasite load would also have reduced an adult's energy levels, productivity, and, in women, fertility, thus occasionally provoking the demographic crisis to which we have referred previously. Whilst the Indus region's populations were unlikely to have understood the connection between malaria and its mosquito vector, they must have observed the differences in malaria frequency among differing environmental circumstances and responded accordingly.

Summary

The model we have for understanding the prevalence and virulence of malaria in the Indus Civilisation between the date when it was first introduced in *c.* 4000 BC and 1800 BC, leads to an understanding of its effect on the Indus Civilisation in terms of morbidity and mortality, human demography and social structure. It also poses the question about the extent to which it may have inhibited the civilisation's growth and development, particularly in the period that ended with the transition from the Early to the Mature Harappan phase, in 2600 to 2500 BC.

The available evidence makes it likely that, due to the complexity of the disease and the behaviour of its vector, the effects of malaria can only be properly understood at a sub-regional or even local level, after taking into consideration differing microevolutionary trends, geography, climate, hydrology and human behaviour that existed within the vast area occupied by the Indus Civilisation. It is, of course, quite possible that in the Early Harappan, from 3300 to 2600 BC, when environmental factors at the time were conducive to the spread of both the vector and the disease, the depressive effects of malaria meant that the huge expansion that eventually occurred in the Mature Harappan might even have occurred earlier. Growing population densities and settlement nucleation at the time would then have provided the *Anopheles* vectors with new or alternative food sources, enhancing its ability to thrive and reproduce. By the Mature Harappan, however, because of ecological and geographical changes and human interventions, e.g. improvements in farming techniques, we see malaria being gradually reduced to a much more manageable level, thus helping that society to thrive.

As well as the cause of what can only be described as both multiple mortality and morbidity, malaria can also lead to many conditions, e.g. delayed skeletal maturation, neurological conditions and cognitive impairment, as well as increased susceptibility to infections such as tuberculosis and those caused by helminths. The risk of malaria was increased with population growth, reduced mobility, and the growing practice of different forms of agriculture, irrigation, and land clearance.

Malaria knows no boundaries and, on the other hand, contributed to the inhibition of the growth of the contemporary, more primitive chalcolithic cultures peripheral to the Harappans who were, unlike them, prevented from fully emerging from an earlier stage of development. Looking to the future, it is still a hope that the successful application of molecular biology and the possibility of extracting and sequencing sufficient ancient DNA from human skeletal remains will confirm what is known or inferred about the prevalence of malaria by the presence of sickle-cell disease. We may even be able to extract the ancient DNA of *plasmodia*. However, it may be impossible to do this, because of the inability of available skeletal samples to produce any results.

Traumatic Injuries

Wounds to the skin, muscle and internal organs cannot be determined from the palaeopathological record. The opposite is true, of course, of fractures and other injuries which affect the bones, leaving recognisable traces even on healthy ones. Next to degenerative joint disease, the most common pathological conditions affecting skeletons remains result from trauma, although the amount and types may differ from population to population and period to period. In fact, the percentage of bones from the Indus Civilisation that were fractured during life is not particularly large, although it is possible to determine that trauma often becomes more common in food-producing populations.

Of course, the real frequency may well have been higher, as a negative diagnosis cannot be confirmed in the case of the numerous incomplete skeletons. As far as the ancient world is concerned, it appears that the risk of fracture is inversely related to the progress of civilisation.[118] Ortner and Theobald have divided trauma to the skeleton into two categories, accidental or unintentional, such as the fracture from a fall or workplace injury, punishment, or intentional trauma or injury principally caused by another human – especially in warfare or inter-personal conflict, which mainly results in broken long-bones or a fractured skull – as well as trauma induced by pseudo- or actual therapeutic surgical procedures, for example, cranial trepanation.[119]

A good example is the fracture of the forearm, which dominates the palaeopathological record of the ancient world. It can be characterised as breaks in the continuity in the middle of the ulna, a parry fracture, resulting from a defensive movement, holding up an arm to parry blows aimed at the head or body; or lesions of the lower portions of the radius and the ulna usually caused by falls, or breaking a fall with the arm. Most of these fractures resulted in poor healing and the resultant persistent dysfunction, and often the union shows signs of periostitis. The common forearm fracture usually occurs when a person falls forward

[118] Angel 1974: 9-18.
[119] *Pre-Roman Diseases*: 248.

and breaks the fall with a reflex gesture of an outstretched hand, a Colles' fracture, which usually affects the lower end of the radius, with or without the involvement of the ulna. The next most common fracture site was the vertebra, particularly the lower thoracic vertebrae.

Paediatric fractures are rare. As Ortner and Theobald point out, remodelling associated with growth generally obliterates any evidence of childhood fractures, and that it may be that evidence of these fractures and other trauma may not be seen unless the child died as the result of the trauma or shortly afterwards.[120] It is, of course, likely that children suffered from unintentional trauma, particularly those who worked in agriculture or sweatshops in urban communities.

Traumatic lesions reflect the culture in the population in which they occurred. Head trauma usually increases with food-producing and pastoral populations as elsewhere. Well authenticated cases occur at Kalibangan.[121] For example, an adult male, found in Grave 11, had vertical cut marks to the inner side of his left knee in the medial condylar region of the left femur and tibia. The sharp cut was 3 cm deep and 9.5 cm long and shows no sign of healing. It appears that the man was hit by a sharp instrument, possibly something like a bronze hafted axe and did not survive the violent incident, probably because of severe blood loss and because the wound shows no sign of healing.[122] Certain marks of injury caused by a sharp weapon on the bones of two individuals have raised a doubt as to whether the Mature to Late Harappan site of Lothal was the scene of some endgame battle of the Indus Civilisation. Only one (SK 11), however, belongs to the Late Harappan (Phase V) and an injury to the tibia of one of the younger males would not normally be fatal and does not point to combat.[123] In her discussion on cranial trauma, Lovell describes her findings and the work of others as indicating interpersonal violence, including blunt-force injuries to the head; many were fatal, i.e. victims from Cemetery R-37 at Harappa, Lothal, Farmana, and Kalibangan.[124]

New evidence of violence-related trauma found among remains unearthed from the Mature Harappan cemetery of Rakhigarhi, *c.* 150 km northwest of Delhi. In the left frontal area of the cranium of an adult female (BR12), a depression fracture might have been caused by a direct blow to the skull with a round-tipped object. Since the traumatic lesion of BR12 had completely healed, the skull fracture is very unlikely to have been the direct cause of death. This points to evidence of interpersonal violence that might have occurred among the Indus Civilisation and proof of whether Rakhigarhi society was a hierarchy beset by structural violence.[125]

From the skeleton of a female over the age of 30 from Balathal of the Ahar-Banas People era (BTL 1999-3), there is evidence of a vertebral compression fracture as well as degenerative joint disease. The fracture is to the ventral surface of one thoracic vertebra and five vertebrae adjacent show evidence of vertebral osteophytes which had ankylosed and resulted in the fusion. It is not thought that this was the result of cancer metastases; her

[120] *Pre-Roman Diseases*: 249.
[121] Kennedy 1990a: 72.
[122] 122 Sharma 1969: 106; *Departed Harappans*: 94.
[123] Rao 1979: 145-146, 162-164; *Lothal*: 219.
[124] *Bioarchaeology*: 173.
[125] Lee *et al.* 2019: 362-367.

condition is likely to have been the result of the injury. She also had a pelvic ring fracture to her left acetabulum and necrosis of the left femoral head. This is not uncommon in antiquity and is often associated with hip dislocation. If not properly treated by reduction and immobilisation, it will result in permanent disability. Perhaps the injuries were caused by one traumatic incident.[126]

The Mohenjo-daro Skeletons

The early excavations at Mohenjo-daro brought to light 37 disarticulated skeletons of men, women and children in largely abandoned rooms of the urban settlement, streets, courtyards and staircases, completely devoid of any evidence of burial (Figure 8). Dating to the early part of the Late Harappan, these circumstances led Marshall to suggest sudden death, perhaps disease or famine.[127] Mackay, later supported by Wheeler, suggested an external attack leading to a massacre of the occupants, perhaps in a desperate attempt to flee.[128] The first study of the skeletons supported this idea, identifying some cut-marks and fractures.[129] This scenario was first challenged by George Dales, who, after his own excavations at the site, found that the individuals, although deposited in a haphazard way, are not contemporary chronologically and nothing found with them suggests military action or deliberate trauma.[130]

The skeletons have been re-examined by Kennedy, who found only two cases of trauma, one on Skeleton 10 from the excavations of Marshall and the other on Skeleton DK7411 of those undertaken by Mackay.[131] What we are unable at present to determine is why these 37 individuals were treated as they were. Of course, we understand that soft-tissue trauma does not necessarily leave skeletal markers, but the answer lies elsewhere. A recent study of the physical and anthropological perspective supports Kennedy's conclusion that the evidence pointing to the invasion theory in the Late Harappan phase to be nothing more than fanciful.[132] The skeletons may be from sufferers of a disease, possibly malaria. An alternative to Wheeler's disproven massacre theory is that the city of Mohenjo-daro suffered extensive flooding in the Late Harappan and that people may have died because of the virulence of water-borne diseases such as cholera. There is evidence of flooding in the stratigraphy of the late 3rd and early 2nd millennia BC, when the River Indus was prone periodically to break its banks. The city's brick platforms and fortifications may have been built partly to provide a form of flood defences.

[126] Robbins *et al.* 2007: 55-56.
[127] *Mohenjo-daro*: 79-81, 107-108, 184-185, 222-223, pls. XLVI(a)-(b) and XLIII(a); Sewell and Guha 1931, vol. II: 599-648.
[128] *Further Excavations*: 116-118; *Indus Civilisation*: 71-72, 129-132.
[129] Sewell and Guha 1931: 599-648; *Further Excavations:* 613-638.
[130] Dales 1964: 36-43.
[131] *Trauma and Disease*: 426-427, 429.
[132] Walimbe 2011: 35-43.

Figure 8. Disarticulated skeletons from Mohenjo-daro, found above southern wall of Room 74, House V; Late Harappan Phase (after *Mohenjo-daro*: plate XLVI(b)).

Skeletal Trauma at Harappa – telling a different story?

Robbins Schug and her colleagues have re-examined the 157 individuals recovered from Area C of Cemetery H (Late Harappan) and Cemetery R-37 (Mature Harappan) during the excavations undertaken at the site between 1929 and 1947, a relatively large skeletal collection which compared evidence for cranial trauma among burial populations in this major urban centre through time to assess the hypothesis that Indus state formation occurred as a peaceful heterarchy.[133]

Their conclusion was that the prevalence and patterning of cranial injuries, combined with striking differences in mortuary treatment and demography among the burials, points to interpersonal violence in the Indus Civilisation that was structured along lines of gender and community membership. The results support a relationship at Harappa among urbanisation, access to resources, social differentiation, and risk of interpersonal violence. Furthermore, the results contradict what they describe as a dehumanising and unrealistic myth of the Civilisation as exceptionally peaceful.

To be more specific, it has been shown that violent injury was a fact of life for some of Harappa's residents. Some experienced, enacted, and witnessed violence, which varied in prevalence by sex, age, and mode of internment. Social differentiation and exclusion emerge from their data. They point out that the uneven risk for violence and uneven access to resources may further

[133] *Peaceful Realm?*: *passim*.

indicate that the inhabitants of the Indus Civilisation based their society on exclusion and this structure determined the risk for personal violence. It might appear that they would also have gone through a process of state formation that was not unique in the 3rd millennium BC.[134] However, this evidence seems to be in contradiction to the overall impression gained that the Indus Civilisation was egalitarian and further evidence needs to be untaken to understand more the place of this violence in their society.

Lovell has also published in preliminary form some of the adult skeletons excavated from Cemetery R-37 in 1987 and 1988.[135] She reported that lesions were observed in six of 19 complete skeletons from primary contexts, affecting a cranium, rib, radius, vertebra, scapula, and phalanges. Lesions affecting a rib, vertebra, pedal phalanx, and cranium were recorded for four additional individuals from clearly secondary contexts (Table 9). This data permits additional insight into the pattern of trauma at Harappa, in which four females, three males, and two non-adults suffered violence-related craniofacial trauma. Lesions affecting a scapula in one female, the posterior cranium and a rib in another female, and a manual and a pedal phalanx in two males, neither support nor contradict their conclusion that interpersonal violence at Harappa was directed toward females, although females did incur significant injuries. The low frequency of possible violence-related lesions in the high-status Cemetery R-37, however, Lovell suggests, may support the proposal that violence at Harappa was socially differentiated.

Non-Specific Periosteal Reactions and Infection Related to Trauma

There is evidence of one individual demonstrating a non-specific periosteal reaction – an adult (H.698) from stratum 2 of Cemetery H at Harappa.[136] This individual H.698 had periostitis on a fragment of her tibial diaphysis. Because the tibia is fragmentary and the antimere is not present, this was recorded as a non-specific periosteal reaction. There is no evidence of trauma, however it also cannot be ruled out, as this individual also suffered from four violent injuries to her cranial vault.[137] Evidence for infection related to trauma was found on two individuals from Harappa Area G.[138]

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[134] *Peaceful Realm?*: *passim*. Reviewed by Lovell in *Bioarchaeology*: 173-174. More specifically, cranial trauma consistent with interpersonal violence from the urban cemetery R-37, affected three adult females, and one adult male had at least one depression fracture on the cranium. One of the affected females demonstrated evidence of recidivistic trauma. In addition to the healed depression fracture on the left occipital bone, she had a nearby possible ossified hematoma, a healed rib fracture, and a healing Colles' fracture of the right radius. The cranial traumata are interpreted as evidence of inter-personal violence and considering the skewed sex ratio and the recidivist injuries on one female, it is possible that the risk of violent injury in the urban phase was gendered, with females at greater risk of violence. Nine individuals from the post-urban period demonstrated evidence of cranial trauma: three of eight individuals from Cemetery H (stratum II) and five of ten individuals from Area G. The human skeletal samples from Harappa have the highest prevalence of interpersonal injury. 12 individuals demonstrated evidence of craniofacial trauma, including two immature individuals, seven adult females, and three adult males. The prevalence of injuries in the mortuary assemblage increased through time, from 7.5% of crania affected in the urban Cemetery R-37 to 44.4% of crania in the post-urban period, and adult females had the highest risk of injury. Children (approximately five years of age) were affected only in the Area G assemblage. The type of injuries also varied over time. Blunt force trauma to the cranial vault, inflicted with a club-like implement, was the primary type of injury at Harappa, but two male individuals from Area G had healed broken noses and one of these males also had a sharp force trauma injury to his glabella.

[135] Lovell 2014a: 1-4.

[136] *Infection*: 6.

[137] *Peaceful Realm?*: 140.

[138] *Infection*: 6, figs. 3 and 4a-b.

Table 9. Trauma in human remains at Harappa (1987 and 1988), (after Lovell 2014a: 1-4, Table 1).

TRAUMA IN HUMAN REMAINS AT HARAPPA IN 1987 AND 1988						
Feature	**Age**	**Sex**	**Primary Burial**	**Completeness**	**Mechanism of Injury**	**Traumatic Lesion**
H87-49b	A	U	No	Incomplete	Direct, sharp force	Right second pedal phalanx: localized penetrating injury on dorsal surface with associated inflammatory response (isolated element)
H87-49d.2	MA	F	Yes	Complete	Indirect	Mid-thoracic vertebra: crush fracture
H87-90a	A	U	No	Commingled	Indirect	Mid-thoracic vertebra: Schmorl's node (isolated element)
H87-93b	A	U	No	Commingled	Indirect, blunt force	Rib shaft: healed fracture (isolated element)
H87-127a	MA	F	Yes	Complete	Indirect	Third lumbar vertebra: crush fracture
H87-134a	MA	F	Yes	Complete	Direct, blunt force	Superior left occipital bone: healed depression fracture
					Direct, blunt force	Superior left occipital bone: possible ossified hematomas
					Indirect	Right radius: healing fracture of distal shaft (Colles' fracture)
					Direct, blunt force	Rib: healed fracture of shaft
H87-148a	OA	F	Yes	Complete	Direct, blunt force	Left scapula: healed fracture of lateral margin and body inferior to glenoid fossa
H88-4b	MA	M	Yes	Complete	Indirect	Left manual phalangeal shaft: healed fracture on palmar aspect of distal shaft (cortex badly eroded)
H88-185b	YA	U	No	Isolated calotte	Direct, blunt force	Right frontal bone superior to the brow ridge: possible depression fracture
H88-220a	YA	M	Yes	Complete	Direct, blunt force	Left first distal pedal phalanx: healed impaction fracture at base, with associated marginal lipping (head of the phalanx not preserved)
YA=young adult; MA=middle adult; OA=older adult; A=adult of indeterminate age; F=female M=male; U=sex indeterminate						

[After Lovell 2014a: 1-4, Table 1]

Osteoarthritis and other Degenerative Diseases of Bone

Throughout antiquity many adults suffered from degenerative disease, such as osteophytosis and by far the most common, osteoarthritis. Osteoarthritis is a disease of the joints which includes many different syndromes. As the term implies, it is an inflammatory condition of the joints, a common factor in any of its different manifestations. Rheumatoid arthritis, a significant disease today, was not then known. Inflammation may occur in osteoarthritis, but it is neither the initial nor most significant factor, the most important usually being mechanical stress. The effect of this stress in stimulating arthritic change can be cumulative, thus it is also usually correlated with age.[139] The form that has received the most attention by palaeopathologists has been osteoarthritis of the spine.

Degenerative joint disease and primary osteoarthritis and osteoarthrosis are not a single disease, rather they are the result of a variety of patterns of joint failure with various causes. Current opinion amongst clinical rheumatologists is that osteoarthritis is largely an age-related phenomenon with varying genetic predispositions. Secondary osteoarthritis may therefore only be partly due to other conditions. Lesions in lumbar vertebrae can be caused by bending and lifting, and in the thoracic region by constant turning and pivoting movements.

Females suffered most from degenerative lesions and disfiguration of their vertebrae, most often in the lumbar and lower thoracic region, probably suffering from lumbar pain and sciatica more frequently than males, even though the average age of the females was likely to be about ten years younger than males. The causes are to be found in very demanding domestic and agricultural labour, combined with frequent pregnancy and childbirth. Osteoarthritis occurs in both hunter-gatherer and food-producing communities in the Indus region, as in any other part of the prehistoric world.

Lovell has studied joint changes in the vertebral skeleton in human remains excavated in 1987 and 1988 at Harappa.[140] The sample consists of 23 complete skeletons from primary burial contexts, the partial remains of more than 69 other individuals, and hundreds of skeletal elements from secondary contexts, totalling 3,084 vertebral joint margins and articular surfaces. Marginal bone proliferation, pitting of articular surfaces, eburnation, and ankylosis were examined macroscopically for vertebral body margins and surfaces and posterior apophyseal facet joints.[141]

Lovell points out that marginal lipping is far more prevalent on the vertebral bodies than on the apophyseal facets, and surface pitting is also more frequent on vertebral bodies, although its expression is relatively low overall. Cervical vertebrae in this sample exhibit the same amount of marginal new bone and much more surface pitting of the vertebral bodies than do either thoracic or lumbar vertebrae; the cervical segment also exhibits the most severe expressions of both types of lesions. In addition, although the frequencies of cervical and

[139] *Pre-Roman Diseases*: 252.
[140] Lovell 1994: 149-164. There are also examples of vertebral osteophytes, degenerative modifications to the spine that usually appear before the age of 30 and are well advanced into old Age. It is often associated with osteoarthritic remodelling of the bone and is often a common response to mechanical stress and weight bearing, such as carrying heavy loads on the head and shoulders. The condition may also result from trauma, rheumatoid arthritis, or infection, and can sometimes occur in other postcranial bones. See Lovell and Kennedy 1989: 89-92.
[141] *Bioarchaeology*: 174.

lumbar posterior facet involvement are similar, the cervical facets exhibit much more severe lipping as well as the only cases of eburnation and ankylosis. Pitting of the posterior facets is most common in the lumbar segment, but the cervical examples are the only severe cases.

At Harappa, it is possible to determine from the human skeletal remains, several cases of severe arthritis in the neck, including fusion of adjacent vertebrae. This could be associated with stress to the neck, such as would occur from carrying heavy loads on the head. Osteoarthritis can also be identified in the Rakhigarhi skeletal remains, with some parts of the postcranial skeleton, such as the knee, ankle and vertebral joints of three individuals exhibiting evidence of osteoarthritis (BR18-02; BR31). This again may be related to carrying loads on the head.[142]

The severe joint changes in the cervical spine specifically result from trauma, probably accumulated microtrauma, from the stresses of agricultural or small-scale industrial activities. There are apparently no age or sex associated patterns in the frequency of arthritis, although this result may be influenced by the small proportions of the total sample for which age and sex could be determined.

Dental Disease[143]

The changing pattern of dental disease in the Indus Civilisation during its prehistory is partially attributable to both an evolving demographic structure of the population as well as changing cultural and ecological conditions. Equally, teeth and the supporting tissue can also be affected by many diverse disease conditions.[144] The size and shape of teeth can be affected by systematic disease, e.g. infection and malnutrition that occur during foetal, infant and childhood dental development. Systemic diseases can also leave observable defects on the enamel, called enamel hypoplasia. The surface of teeth can also be destroyed by bacteria, which results in dental caries, which can destroy the tooth to the point where the pulp cavity is exposed to infection and can eventually invade the bone and produce inflammation and abscesses. Teeth can be traumatised by gritty materials in food, violence, and using teeth as tools.[145]

Other areas of the mouth can also be affected by disease, i.e. gums may be inflamed due to irritation from plaque or infection, which will result in periodontal disease and re-absorption of alveolar bone. The subsequent exposure of the tooth roots with alveolar recession can result in root caries and the loss of the tooth. The supporting bony tissue of the jaw can be subject to inflammation just as bone in other parts of the body. In archaeological contexts, the dental pathologies most regularly seen and recognised are caries, periodontal disease, dental abscess, antemortem tooth loss, dental attrition, and enamel hypoplasia, although, the methodology for analysing many of these dental pathologies is inexact and therefore sometimes an accurate diagnosis cannot be made.[146]

The examination of both paediatric and adult teeth has also had an epidemiological and environmental dimension. It is possible to link the increased frequency of enamel hypoplasia

[142] Shinde *et al.* 2018: e0192299; Woo *et al.* 2018: 111-120.
[143] For general overview and methodology of study, see Lukacs 1990: 315-332 and *Bioarchaeology*: 175.
[144] *Pre-Roman Diseases*: 255-256.
[145] *Pre-Roman Diseases*: 255-256.
[146] *Pre-Roman Diseases*: 255-256.

found in skeletons with the beginning of childhood epidemics, when the increase in population numbers could maintain the disease organisms. However, there is the possibility that the severity of enamel hypoplasia in the young may be inversely associated with the age of death. Some have suggested that stress, which produces hypoplasia, may be linked to factors resulting in the death of the individual.[147] In contrast, some have suggested that hypoplasia is indicative of individuals who survive stress, unlike individuals who die before their teeth can be affected.[148]

Dental disease from the Pre- to Late Harappan phases has been extensively studied by John Lukacs, and his work has been a significant contribution to our understanding of health and nutrition in the periods as well as the dental disease from which they suffered. Much of the work of Lukacs, however, has been concerned with dental morphology, but this does not need concern us. What does concern us is his statement that patterns of dental disease among the Indus Civilisation are consistently based on early and incomplete reports by non-specialists, which precludes accurate diachronic analysis of dental disease and its relationship with increasing agriculturalism in the region.

The Pre-Harappan site of Mehrgarh (Mehrgarh I-II) offers a first glimpse of the dental pathology of early farmers. A sample of 16 individuals has been studied, but although most of the teeth are isolated from their normal anatomical position, many specimens are nearly complete. All deciduous teeth are free from caries and of the permanent teeth, 2.3% of the sample show evidence of caries; all found on molar teeth, usually on the occlusal surface of the crown. Of the molar teeth, 101 are carious, 5.9% of the sample.[149] The low caries incidence reported from Mehrgarh is typical for either hunter-gatherer or mixed subsistence economies elsewhere.[150] This is in stark contrast to the very high caries rates (>29.6%) found among later full-time farmers of the Early and Mature Harappan phases, whose diets are high in carbohydrates and sugars. As Lukacs points out, the adoption of new and different kinds of food preparation produces a significant change in the magnitude and type of stress on both teeth and jaws, and dietary patterns and dental stress leave clear markers of attrition and changes in the incidence of dental pathology.[151]

During the Mature Harappan phase, four dental diseases occur with some frequency at Harappa and Mohenjo-daro: alveolar resorption (also known as periodontal disease), antemortem tooth loss, dental caries, and dental abscesses. The evidence shows that alveolar resorption is by far the most frequent dental disease (Tabel 10).

Caries and antemortem tooth loss follow in frequency but are less common. The least frequent is the one case of a dental abscess from the R-37 cemetery at Harappa (Pot No. 12(a). This is compatible with what one might expect from a sedentary, agriculturally based population. Dental abscesses, a condition associated with increased masticatory stress, imposed by a tough, fibrous and poorly prepared diet, symbolic of hunter-gatherers, are very infrequent in the Indus Civilisation. The moderate frequency of dental caries and antemortem tooth loss is also typical for agriculturally based populations. The softer foods resulting from dependency

[147] *Human paleopathology*: 280-287.
[148] Smith *et al.* 1984: 101-136.
[149] Lukacs 1983: 390; Lukacs and Minderman 1992: 167-180. See also Lukacs 2002: 41-61.
[150] Turner 1979: 619-636.
[151] Lukacs 1982: 301-307.

on milled cereals and the high-carbohydrate intake of the population of such urban centres such as Harappa and Mohenjo-daro, caused a reduction in the degree of dental attrition and an increase in the overall frequency of dental caries formation. Reduced dental attrition permits food particles in the mouth to become lodged in the inter-cuspal fissures of the tooth crown, providing an ideal environment for the bacteria responsible for tooth decay.[152]

The frequency of antemortem tooth loss and dental caries seems to be a common feature amongst the major urban centres of the region. As cariogenic decay proceeds to destroy the crown of the tooth and exposes the dental pulp cavity, the tooth is eventually and prematurely shed. The corresponding incidence of tooth decay due to caries and the frequency of antemortem tooth loss are suggestive of a causal relationship. Alveolar resorption, the most commonly occurring dental disease amongst the population of the Indus Civilisation, may also be caused by several factors, but the actual cause is still unknown.[153] One thought is that infection is caused by *pyorrhoea alveolaris*, an infection of the gums (gingival tissue) and tooth sockets. Its occurrence is facilitated by the absence of dental hygiene and transmitted by communal use of kitchen utensils. A second cause is heavy masticatory stress, from prolonged chewing, probably of poor quality (or undercooked) meat or stress due to the unintentional inclusion in bread of such things as sand, grit, and flecks from the millstone. Alveolar resorption often accompanies antemortem tooth-loss, and it has been suggested that most of the alveolar resorption is due to antemortem tooth-loss, which may tell us something about their nutritional state. A study of children's teeth from Mohenjo-daro shows pre-adolescent children affected by carious formation.[154]

The impression derived from a study of the dental pathology of the occupants of Harappa and Mohenjo-daro is that they exhibit a dental disease pattern consistent with a dependency on agricultural subsistence strategies. The disease profile suggests a reduction in masticatory stresses and its associated conditions, but also an increase in dental caries due to soft foodstuffs and increased carbohydrate intake. They probably paid the price in pain and discomfort for these soft and easily masticated foods.[155]

The study by Lukacs of the teeth from the 36 individuals from Cemetery R-37 at Harappa excavated in 1987-1988, shows that, other than gross linear enamel hypoplasia, he recorded incidence of abscesses (18.4%), antemortem tooth loss (31.7%), dental caries (43.6%), and alveolar resorption (52.6%). Included were also hypercementosis (4.9%) and pulp chamber exposure (17.1%). The dentition of the population group from Harappa clearly exhibits a dental pathology profile typical of a population whose subsistence base is agriculture. Dental caries at Harappa is present in 6.8% of the teeth and 43.6% of the more completely preserved dental specimens.[156]

The dental health of the inhabitants of the graves of Rakhigarhi was relatively good and the overall prevalence of oral pathologies was very low. One thing of special interest is the evidence for dental attrition. From the site, several severe dental attritions were observed, mainly seen on the anterior teeth of the maxilla of middle-aged and elderly adults, particularly on their

[152] Lukacs 1982: 305.
[153] Lukacs 1982: 305.
[154] Lukacs 1982: 305-306.
[155] Lukacs 1982: 306.
[156] A caries correction factor was used to permit an estimate of caries induced antemortem tooth loss in calculating the caries prevalence.

Table 10. Incidence of dental pathology at Harappa and Mohenjo-daro (after Lukacs 1982: Table 28.4).

INCIDENCE OF DENTAL PATHOLOGY AT HARAPPA AND MOHENJO-DARO						
Dental Pathology	**Harappa**		**Mohenjo-daro**		**Sites Combined**	
	N	**%**	**N**	**%**	**N**	%
Abscesses	1	1.43	0	0	1	1.02
Alveolar resorption	7	10.1	2	7.14	9	9.13
Caries	4	5.71	3	10.71	7	7.14
Antemortem tooth loss	5	7.41	2	7.14	7	7.14
Individuals affected	13	18.57	6	21.43	19	19.39
Total skeletal sample	70		28		98	

[After Lukacs 1982: Table 28.4]

lingual surface. This may reflect dietary habits, food preparation methods, or occupational activities of the population. Lingual surface attrition of maxillary anterior teeth may be due to forceful holding or pulling of animal skins between the teeth for the purpose of softening it, or activities related to spinning or weaving.[157]

All dental lesions are present at higher rates in this Harappa sample than were reported in previous investigations and important differences in prevalence of dental disease occur between the genders, with some female teeth showing significantly high frequencies of dental caries. This may reflect important dietary differences between males and females, or may reflect occupational specialisation. This also goes back to childhood, as enamel hypoplasia detected on deciduous teeth affects females far more than males.

Whilst on the face of it the Indus Civilisation may have been egalitarian, with the absence of social elites, inequalities did certainly exist between genders in both childhood and adulthood. The other significant factor is that from both an individual and tooth count data, it is possible to see a pattern of dental pathology as subsistence agriculture becomes more intensive and as food preparation, processing, and storage technology become more efficient.[158]

Conclusion

From a study of the skeletal evidence, many will tentatively assume that the overall health of the population of the Indus Civilisation is characterised by some incidence of traumatic injury, particularly in the Late Harappan, low incidence of chronic disease, and a general absence of malignant neoplastic disease. Of metabolic disease, based on an inadequacy of nutrition, adult scurvy has not yet been identified, although rickets has been detected on some of the crania studied from the sites of Chandoli and Nevasa, located in Maharashtra in India and dated *c.* 1800-1500 BC.[159] However, they are infrequent and their wide distribution does not point to patterns or trends and are not necessarily an effect of the cultural environment.[160]

[157] Shinde *et al.* 2018: e0192299; Woo 2018: 111-120.
[158] Lukacs 1992: 133-150.
[159] For a summary of the lesser developed non-urban societies of the region, see *Rise of Civilisation*: 271-286.
[160] Kennedy 1990: 71.

Table 11. Diseases or conditions identified from Indus Civilisation sites.

DISEASES OR CONDITIONS IDENTIFIED FROM INDUS CIVILISATION SITES	
Disease or Condition	**Site**
Obstetric Obstruction	Harappa
Scaphocephaly	Harappa
Congenital Skeletal Deformities	Kalibangan
Hydrocephaly	Kalibangan
Tuberculosis	Harappa
Localised Infection	Harappa
Bone Infection	Harappa
Chronic Inflammation of the periosteum	Harappa
Maxillary Sinus Infection	Harappa
Leprosy (Hansen's Disease)	Balathal (Ahar-Banas Complex) Harappa
Traumatic Injury	Balathal (Ahar-Banas Complex) Kalibangan Mohenjo-daro Rakhigarhi
Chronic Infectious Disease (?)	Rakhigarhi
Osteomyelitis	Rakhigarhi
Rickets	Chandoli Nevasa
Falciparum Malaria	Mohenjo-daro
Sickle Cell Disease	Mohenjo-daro
Osteoarthritis and Degenerative Diseases of Bone	Harappa Rakhigarhi
Dental Disease	Harappa Mehrgarh (Period I-II) Mohenjo-daro

The diseases and conditions listed here are all chronic and does not take into account the many acute diseases that will have existed at the time. It is also dependent on diseases and conditions identified so far and there may be others that will come to light following further excavation and study.

There is evidence for arrested childhood development, through enamel hypoplasia of deciduous teeth. This is usually caused by malnutrition, acute bacterial, viral or parasite infection. What we do have is inferred incidence of the prevalence and likely virulence of malaria and evidence of diseases such as leprosy or Hansen's Disease. Arthritis of the spine, neck, joints of the knee hands and feet is the most common condition, not unusual for a society based upon agriculture or small industrial workshops.

Does this indicate that the population of the Indus Civilisation were relatively healthy, well-nourished and disease free? It is impossible for a major urbanised ancient society to be free of all forms of bacterial, viral and parasitic disease. What we are blind to, however, is not only those diseases that do not leave lesions on archaeological bone, but that the number of

skeletons studied for their pathology alone, for a society of this size are very few, if compared to other contemporary societies further west (Table 11). The search for cemeteries of this period must be a priority if we are to obtain a much more accurate picture of the disease patterns of the Indus Civilisation.

Robbins Schug has summarised the results of the study of the skeletal remains from Harappa. She found that: (a) Females were most affected by developmental disruptions in childhood as measured by the crude presence of enamel hypoplasia in teeth; (b) There was a low crude prevalence of cranial trauma in the Middle Harappan, which was elevated to a higher rate in the Late Harappan; (c) Leprosy was present at Harappa in the Mature Harappan, but evidence of tuberculosis was found only in the Late Harappan; (d) Infection and traumatic injuries were almost non-existent in the Mature Harappan, but the risk was significantly elevated in the Late Harappan; (e) Adult females had a higher prevalence of traumatic injuries, infection and exposure to infectious disease; and (f) The highest crude prevalence of individuals affected by infection, infectious disease and injuries was observed in both the immature and adult sample from Area G at Harappa.[161]

[161] Robbins Schug 2017: 278-279.

Chapter Four

Diseases of Occupation

After a century of archaeological research into the Indus Civilisation, we know a great deal about its regional and local economy, its settlements, both urban and rural, its overseas contacts, and the sources of commodities for many craft and industrial workshops for manufacturing both precious and utilitarian objects. Whilst we have succeeded in achieving a much greater understanding of the processes and the products, no attention has yet been given to what working conditions were like and the diseases, trauma, and degenerative conditions the workforce, both men and women, will have suffered as the result of their everyday occupations.

The study of occupational disease and trauma is speculative; it can be difficult to determine whether a disease or condition of injury has been contracted or sustained in an individual's place of occupation, as in the ancient world it is often impossible to distinguish between a work location and the home of the individual – they were often the same place. However, by using the evidence provided by archaeology and human and animal palaeopathology it is possible to identify some of these injuries and illnesses that would have occurred in such workplaces.

There are two very distinct categories of evidence for occupational trauma and disease of the Indus Civilisation's workforce. The first category is that produced by human skeletal remains that exhibit lesions, mostly of osteoarthritis and trauma, which can also help interpret the occupation of those buried there. The second category is based on what we know of the epidemiology and natural history of disease and trauma in an occupational context, and the known physical behaviour of pathogens and their vectors.

Physical Stress

Many who practice very physical occupations are likely to suffer from varied forms of osteoarthritis or 'wear and tear' arthritis,[1] and skeletal changes to certain joints. If someone performs a very heavy manual occupation, which severely stresses the joints, it is possible that a pattern in the skeletons of those who perform similar occupations may well emerge. Of course, other factors may account for osteoarthritis, e.g. obesity and age in the individual, and it is therefore sensible to first look at younger individuals to see if any pattern emerges. If occupationally related skeletal changes are to be of any relevance, then the individual must generally have started in the activity from a relatively young age for a skeletal study to mean anything.

The problem with determining occupationally related disease is that many do not actually effect skeletal changes and often people with identical occupations and stresses react in different ways. Work such as this is controversial and there is still a debate about the present

[1] *Human Paleopathology*: 93-96; *Disease*[3]: 136-139.

status of studies of markers of occupational stress (MOS), which includes investigations of specific markers of musculoskeletal stress and degrees of skeletal robusticity.[2]

The recent resurgence of interest in identification and diagnosis of habitual patterns of activity, as registered on bone and dental tissue, is unfortunately hampered by the inability to formulate reliable standards for recognising MOS and interpreting their underlying causes and thus remains a challenge for the advancement of future research. It is now accepted that many markers of occupational stress can be identified and can support an understanding of the economic and social prehistory of the Indus Civilisation. As expected, some of the best examples of MOS from the Indus region come from its urban centres, which are known manufacturing communities, where occupational and environmental factors were important.

Lovell has examined joint changes in the vertebral skeleton on human remains excavated in 1987 and 1988 at Harappa. Her sample consists of 23 complete skeletons from primary burial contexts, the partial remains of more than 69 other individuals, and hundreds of skeletal elements from secondary contexts, totalling 3084 vertebral joint margins and articular surfaces. Marginal bone proliferation, pitting of articular surfaces, eburnation and ankylosis were scored macroscopically for vertebral body margins and surfaces and posterior apophyseal facet joints. Marginal lipping is far more prevalent on the vertebral bodies than on the apophyseal facets and surface pitting is also more frequent on vertebral bodies although its expression is relatively low overall.[3]

Cervical vertebrae in her sample exhibit the same amount of marginal new bone and much more surface pitting of the vertebral bodies than do either thoracic or lumbar vertebrae; the cervical segment also exhibits the most severe expressions of both types of lesions. In addition, although the frequencies of cervical and lumbar posterior facet involvement are similar, the cervical facets exhibit much more severe lipping as well as the only cases of eburnation and ankylosis that Lovell found. Pitting of the posterior facets is most common in the lumbar segment, but the cervical examples are the only severe cases. She has proposed that the severe joint changes in the cervical spine result from trauma, perhaps accumulated microtrauma, from activity stresses. Apparently, there is no age or sex associated patterns in the frequency of arthritis although this result may be influenced by the small proportions of the total sample for which age and sex could be determined. There is no skeletal evidence from this group to suggest that the population of Harappa engaged in very heavy physical work; this sample exhibits a lower frequency of spinal disc herniation (a slipped disc), vertebral arch separation and osteophytosis.

One activity that may be implicated in the aetiology of the vertebral lesions studied from Harappa is the practice of carrying loads on the head. The degree of osteoarthritis in the spine and left arm of females was greater in urban dwellers than in earlier hunter-gatherers and this pattern may have resulted because goods were carried by females on the head, where the urban poor habitually carry many burdens in this way, whether these be water jars, bundles of laundry, firewood, or buckets of dirt at building and road construction sites.[4] We do know that in the major urban centres domestic water was drawn from local wells and carried to its final

[2] Kennedy 1998: 305-310; *Disease*[3]: 153-154. See also Blau 1996: 143-176.
[3] Lovell 1994: 149-164.
[4] Lovell 1994: 149-164.

destination. The trajectory of the loading stress on the human body is likely to be important in this regard, since individuals carrying loads on their backs, perhaps aided by a sling or tumpline across the forehead, tend to exhibit high frequencies of disk herniation as well as accessory articular facets at the sacroiliac joint. These specific features, however, do not appear in the Harappa skeletal sample. Usually, injuries are found to affect both the upper and lower cervical regions and women were affected as well as men, since they typically carried loads such as bundles of firewood and pots as part of their work. Flexion-rotation injuries were the most common, followed by evidence of either vertical compression or hyperextension injury. Neurological consequences, e.g. paraplegia, typically resulted when the lower cervical region was involved and may point to the mechanisms of biomechanical stresses leading to microtrauma or more serious vertebral injury at Harappa.[5]

The finding that arthritis frequency is poorly correlated with age may be influenced by the small sample size but provides some support for the interpretation that the arthritis lesions in the Harappa population spines may be due more too biomechanical factors than to aging processes. The fact that there appear to be no sex differences in the expression of joint changes in the spines of the population of Harappa does not necessarily mean that males and females engaged in the same forms of physical labour, but the uniformity of their arthritis experience suggests that at least within this socioeconomic group there were not great differences in the intensity of their work.

Healed fractures, nonspecific infection, and systemic physiological stress indicators were each found in less than 5% of this Harappan sample; peripheral joint arthritis was observed in low frequencies and no cases of nutritional deficiency were identified. Although a gender-based division of labour may have existed, most of the population of Harappa studied were not likely to be industrial or agricultural labourers of low socio-economic status but rather urban dwellers of non-elite status, perhaps craftsmen and craftswomen, an interpretation not at odds with the archaeological evidence. However, the dental pathological profile for this sample indicates that a gender division of labour may have existed, with males consuming more protein obtained from eating more meat.[6]

Craft Specialisation

A prerequisite to identifying occupational disease and health in the Indus Civilisation is an understanding of how their industries were organised and structured. Kenoyer, in his review of the organisation of craft specialisation and production, has pointed out that at the start of farming and animal husbandry and the beginnings of urbanisation in the Pre-Harappan phase, it was essential for the expansion of wealth within that society to establish new technologies and new tools. Whilst some of these early technologies had their roots in earlier prehistory, such crafts as pottery production, metallurgy, and the manufacture of faience, carnelian and agate beads reflect the intellectual and creative abilities of the human population of the region, whether the manufacturing process was to produce objects for food growing and production, for the kitchen, tools for the workshop, objects for personal ornamentation, weapons, or objects for ritual and religious use. Together these technologies provided the foundation for even more complex modes of production, sometimes on an industrial scale,

[5] Lovell 1994: 149-164.
[6] Lukacs 1992: 133-150; Lovell 1994: 149-164.

which emerged in the Early and Mature Harappan phases, that were needed to support a growing urban population. In both these phases, specialised crafts appear to have played an important yet varying role in the economic, political, and ritual aspects of society. Even since the earliest excavations of Mohenjo-daro, craft and, subsequently, industrial production processes have been central to our understanding of the society that was produced.[7]

One of the features of craft specialisation in prehistory is that it does not naturally emerge; it is only present where skilled individuals are required by the economy and its natural division of labour. With the emergence of early urban centres and, eventually, a complex urban society, craft specialisation involved the production of manufactured goods by either full- or part-time specialists for re-distribution to consumers, internal or external to that society. Large urban centres such as Harappa and Mohenjo-daro, by their sheer size and location are not only likely to have been of some political and religious significance but appear to have also become important centres of the economy of the Indus Civilisation through trade and the establishment of local industries. In their workshops, located mainly on the urban fringes, we see the development of very distinctive forms of utilitarian, ornamental, and symbolic objects.

The work of the metalworker, the jeweller, the potter, the seal carver, and the bead-maker, for example, have produced objects which we can still see in the archaeological record. There were many others (weavers, spinners and dyers of textiles, leatherworkers, woodworkers, basket makers), most of whose work is lost to us, who would have played roles in the manufacturing economy equally as important as those who produced non-perishable objects. It is likely that some objects were made simply for use in these large urban centres where they were made, and may even have had exclusive use if the object were for ritual purposes. Alternatively, objects such as the distinctive black-on-red painted pottery and steatite seals and carnelian beads are found spread through the whole of the world of the Indus Civilisation, as well as externally into what are now Afghanistan and the Gulf and further west and south. Whilst there was a general conformity in artefact styles in the Indus Civilisation, there was also local variation in both style and taste. Within that framework, particular sites may have become primary manufacturing centres for certain items, dictated by the local availability of raw materials, as well as for socio-economic and religious reasons.

According to Kenoyer, it has been shown that some particular crafts (seal manufacture, stoneware bangle, carnelian bead production) may have been segregated to control and ensure the security of the manufacture of these high value items.[8] On the other hand, some crafts (metalworking. the manufacture of pottery) would have been segregated for more basic reasons, i.e. because of the noise, smell and heat they produced, as well as the availability of water supply, labour, and raw materials. The manufacture of standardised items, e.g. weights and measures, seals, elements of metallurgy, or even bricks, may well have been regulated by some form of centralised oversight.[9]

As Heather Miller has pointed out, the groupings of craft production seem to have been predicated by other factors, including: (a) the nature of the craft, whether particular

[7] Kenoyer 1996: 1-2.
[8] Kenoyer: 1-2.
[9] Kenoyer 1996: 1-2.

processes are required, i.e. the use of fire and high temperatures; (b) knowledge relationships and manufacturing requirements within the groups; (c) what constituted distinct crafts, the value of the goods produced and the likely consumers; and (d) ideological beliefs concerning the proper placement of manufacturing within city centres.[10] It is also possible to understand that the workplace and living quarters of these workers may well have be one and the same, existing side-by-side, divided by narrow alleyways and streets, and, probably, in the case of certain trades (shell workers, potters, metal smelters), ringed by dumps of the discard of their craft. There would have been no escape from unhealthy conditions, even at times when they were not at work, from the fumes, smells, wastewater, and heat. Some cottage industries, such as spinning and weaving, may have had a domestic base, perhaps outside the urban centres.

Linked to location, Kenoyer has also pointed out that to understand the differing roles of craft in the Indus Civilisation it is important that we distinguish four categories of craftsmen who worked in Harappan urban centres: (a) those processing local materials using simple technology – woodworkers, producers of terracotta, builders); (b) those using imported materials with simple technology – chipped stone, ground and pecked stone; (c) those using local materials, but having more elaborate and complex technologies – stoneware bangle makers, potters who made fine wares, those who practice wood inlay; and (d) those using imported materials, but with complex technologies – agate bead makers, seal carvers, copper and bronze workers and users of precious metals, shell and faience workers.[11] It is in this context that we very much begin to grasp both the location, but also the relationship between the environment, raw materials and the manufacturing process, if we are to understand anything about the health of the workers who undertook this manufacturing.

The specific evidence from the major urban centres means that these views can be substantiated by the categorisation into crafts, industrial, services, and other occupations. The craft processes includes potters and craftsmen in various materials (wood, shell, bone), ivory workers, jewellers, seal carvers, bead makers, and metalsmiths. The industrial category would include miners, metal smelters, carpenters, stone masons, brickmakers, builders, seamen, shipwrights, riggers, and some textile workers. The service industry included sewer cleaners and water drawers, servants, and other occupations associated with urban management. The final category will have encompassed elite workers, such as scribes and possibly priests. The rural workforce, while including some of these would also have comprised farm workers and herders. Each would have faced the particular risks and hazards of their occupation, which could have ranged from contracting serious diseases and infections to damage to eyesight, hearing, and the effects of industrial accidents. This chapter takes a look at seven specific examples: textile workers, leather workers, copper smelters and other metal workers, bead makers, seal carvers, sewer cleaners, building workers, and herders.

Smaller Trading and Craft Centres

Outside the major urban centres there existed a vast number of smaller sites that exhibit evidence of craft specialisation and industry. A typical one illustrating this, as the potential to understand the nature of smaller scale manufacture and the risks to the workforce and their living standards, was the village of Gola Dhoro, 0.5 km north-east of Bagasra on the Gulf of

[10] Miller 2008: 37-51.
[11] Kenoyer 1992: 39-54.

Kutch in the Gujarat. The site extends over 1.92 ha and rises to 7.5 m above the surrounding area. This small settlement of the Mature and Late Harappan phases, excavated between 1996 and 2005, has revealed evidence for trade and manufacture, as well as highlighting the importance of these smaller settlements in the development of the Indus Civilisation, far removed from the core area.[12]

The settlement probably began as a small farming village at the end of the Early Harappan and subsequently acquired a fortification wall, 5.20 m wide, built in three successive stages in the northern half of the site. This wall enclosed an area of *c.* 2500 m^2, containing residential houses and craft workshops. There are indications, however, that some of the population lived outside the fortified area to the south. Studies to date have shown that the population manufactured objects of shell, semi-precious stone, faience, and copper, besides stockpiling and distributing various raw materials, like variegated jasper and shell, to other Indus Civilisation workshops.

A rectangular structure measuring 17.92 m^2 inside the fortified area contained a large heap of shell bangles, flanked by two heaps of the raw materials: shells of *Turbinella pyrum*. The assemblage also included large quantities of shell wasters and a grinding stone, confirming the identification of a shell workshop of the period. Sorting of shells based on their quality indicates that the shell-cutters of the workshops at Gola Dhoro separated out the inferior quality shell, implying that, unlike the Indus Civilisation, shell-working site of Nageshwar on the Gulf of Kutch,[13] the shell-cutters of Gola Dhoro were not personally involved in the collection of the raw materials, i.e. they would otherwise have helped to discard lower quality shells near the source area, instead of arranging for its transportation more than 100 km to the settlement. Not only were the bangles being manufactured and exported, but they also seem to have been importing raw *Fasciolaria trapezium* shells, believed to have been obtained from Oman, for the manufacture of inlay.[14]

The manufacture and working of faience at the site are implied by large amounts of white rock quartz and layers of silica powder associated with intense burning. X-ray diffraction analyses of the whitish powder samples show it to be of quartz. The heavy stone querns and pestles found in the same area were perhaps used in the preparation of the silica powder. Repeated firing and subsequent crushing of quartz to produce the fine quartz powder for use as an abrasive in the polishing of stone beads can be observed today at Khambhat.

Several stone beads were found, in various stages of manufacture, mainly to the south of the fortification. The assemblage included tapered cylindrical drills made of chert, jasper and chalcedony, as well as constricted cylindrical drills made from a rare form of metamorphic rock ('ernestite'), for drilling soft and hard stones respectively. Another important indication of this industry is the recovery of stockpiles of raw material neatly kept in two clay-lined containers with large amounts of variegated and molten jasper. Both these containers were recovered from a trench close to the interior eastern periphery of the fortification wall. A preliminary observation of these containers indicated that the materials had been sorted based on size and type of raw material. One of the containers contained larger chunks of green, red, and white variegated jasper, a broken stone dish, and a few complete, good quality *Torbinella*

[12] Bhan *et al.* 2005; Brad Chase 2010: 528-543; Chase *et al.* 2014: 63-78.
[13] Bhan and Kenoyer 1984: 71.
[14] Kenoyer 1983: 357.

pyrum shell, while the other contained small chunks of black and white molten jasper that seems to have been used in the manufacture of beads. The absence of manufacturing waste of the green-red-white variegated jasper from the site perhaps indicates that this material was not meant to be used at the site but was carefully stockpiled to be shipped somewhere else for the manufacture of beads. Preliminary research suggests that this material was brought to the settlement from *c.* 70 km south-west, in Saurashtra.

Compared to the small size of the settlement, large amounts of copper objects were also recovered. They included a copper vessel containing eight bangles and an axe, perhaps stored for recycling the precious metal. Other important finds from the southern half of the settlement outside the fortification are unique copper knives with bone handles or protective sheaths meant to protect the sharp working edge of the tool. A unique copper battle-axe (or *parshu*) is also a very interesting find from this area, its small size perhaps suggesting a ritual function. The copper knives were recovered in association with large quantities of animal and fish bones, and we are presently trying to understand if these knives had any functional relation with butchering and the preparation of fish for drying, etc. No evidence of copper melting has been found from the site, but casting is suggested by a few heavily sand-tempered clay crucibles with copper adhering to them.

Golo Dhoro, being a small site, was never expected to yield many seals, but to the excavator's great surprise the site has revealed six inscribed steatite seals, one depicting a one-horned animal, usually referred to as a unicorn, and a standard device engraved in front of it. The back has a prominently projected pierced boss. Seals of this type are common in urban Indus Civilisation sites and they were most probably used in trade and exchange transactions. Stamped impressions of such seals on a terracotta sealing has also been found in the excavation. One of the steatite seals discovered has decorative linear patterns incised on three sides and a deep, scooped out rectangular socket-like cavity on the fourth side; originally it perhaps had a sliding lid to cover the socket and appears to be unique. The occupation of the site continued in the Late Harappan phase, up to 1700 BC, where there are indications that the trade activities and the production of various craft items, use of the fortification wall, writing, and the making of steatite seals, all ended abruptly. It is typical of the smaller urban sites and communities that produced their wealth from manufacturing, as well as agriculture in all its forms, and shows the range of crafts and industries that would not have been uncommon in similar sized centres in this period.

The importance to our knowledge of occupational disease and health is an understanding of the nature and scale of the problems the workforce faced in the Indus Civilisation. Manufacturing was not just the prerogative of the large urban centres. In local craft villages, workers would have faced similar threats to their health, but not on such a large scale.

Textile Workers

The Indus Civilisation textile industry would have been a significant operation, partly centred on the larger urban settlements, such as Harappa and Mohenjo-daro and their peripheral local rural communities, as there is no evidence of cotton growing at Kalibangan, Lothal, Surkotada, or Shortughai, although at the latter is it possible that there was a small linen

industry, as flax has been reported.[15] The size and importance of the textile industry to the Indus Civilisation can be measured in the likelihood that the Great Hall at Harappa (Mound F), with its enclosed long narrow rooms, protected from sunlight, was not a granary but a large textile workshop, particularly for dyeing and finishing. The adjacent circular platforms, it is believed, were used for fermentation of indigo as part of the dyeing process.[16]

Cotton was in everyday use, as we know of cotton being utilised for activities beyond clothing, such as a surface for the drying of bricks, something that would not have been possible if cotton was wholly an elite commodity.[17] From the first stages of grazing the sheep and stocking the raw wool in storerooms, and the growing and preparation of cotton for spinning, to the very last stage of preparing the finished product in the form of a cloth, everything was likely to have been firmly under some sort of direct or indirect control.

Skeletal evidence of spinning and weaving is usually reflected in an increase in the shaft thickness of the humerus, particularly in some male individuals, as compared with the overall sample taken. This phenomenon suggests stress to the shoulders and arms, perhaps as a consequence of weaving. Often osteoarthritis at the metacarpal joint of the thumb is present; it usually appeared more on one side than the other and may reflect occupational strain on the hand, again possibly indicating spinning and weaving. In Harappan samples, there are many examples of such adult osteoarthritis,[18] presumably because the inhabitants of those graves were probably drawn to the major urban centres for the manufacturing work that such a centre would provide. Regarding occupational health, to support the evidence of the human skeletal remains, from an understanding of the natural history of several pathogens and their vectors we can begin to envisage the role of disease in the textile industry of the Harappans.

Wool and Anthrax

Biological by-products of textile production, of both animal and vegetable origins, create a lot of dust and in the case of animal products, spores. One of the most hazardous materials to be handled by textile workers was raw wool, particularly during the process of sorting, washing, and combing, with its dust-borne particles and fungi that can cause disease when mostly inhaled, such as anthrax, also known in England historically as 'wool-sorters' disease'.

Anthrax is an acute zoonotic disease, caused by the gram-positive, spore-forming organism *Bacillus anthracis*.[19] It is primarily a disease of herbivorous animals, especially sheep, goats, cattle, and pigs, but occupational exposure to infected animals or their products (skin, wool, meat) is the usual pathway of exposure for humans. It can form dormant spores that are able to survive in harsh conditions for extremely long periods of time, even decades or centuries. Such spores can be found on all continents, even Antarctica. When spores are inhaled, ingested, or encounter a skin lesion on a host, they may reactivate and multiply rapidly. It is

[15] *Trading Encounters*: 108; Frankfort 1989: 178, 182.
[16] J.M. Kenoyer, from a lecture to Deccan College Postgraduate and Research Institute, *Textiles and Basketry of the Indus Tradition: archaeological evidence and historical legacy*, 10 April 2021. For the Great Hall at Harappa, see *Further Excavations*: 15-22, pls. iv-vi.
[17] *Trading Encounters*: 108.
[18] Lovell 1994: 149-164.
[19] Quinn and Turnbull 1998: 799-818; Logan and Turnbull 1999: 357-369; Dixon *et al.* 1999: 815-826; Lucey 2005: 2485-2491.

believed to have been endemic in many parts of the world, for a very long time, perhaps over a million years.[20]

This is important, because the disease is not usually passed from animal to animal; it is mostly contracted from the spores that live in the soil or contaminate food when grazing. *Bacillus anthracis* has dispersed globally via large and sequential radiations associated with human commerce and trade of animal products contaminated with *B. anthracis* spores.[21] Without human involvement, infected animals typically die within seven to ten days, seeding only the surrounding soil with spores and thus keeping the spread of the disease relatively contained.[22] The potential for dispersion, even among migratory herds, is limited since infected animals typically die quickly before extensive dispersal can occur. Historically, an animal that died of anthrax was scavenged by people for its hair, hide, bones, and even consumed as food, facilitating the dispersal of spores away from a carcass. Indeed, imported spore-contaminated wool and animal hides may have accounted for most anthrax cases in the period;[23] therefore the distribution of *B. anthracis* can be traced to historical human dispersion, trade and migratory patterns. It is believed, for example, that in North America anthrax may have persisted for much of the Holocene, possibly over 10,000 years, having witnessed an ancient introduction.

Humans are infected by direct contact with the animals, animal excrement, or by contaminated animal products, such as wool. The infectiveness of the pathogen for humans is, however, relatively low and there would not have been a huge number of cases, but enough to cause both mortality and morbidity and raise concern amongst Indus-region wool workers. It is inevitable that some of their sheep would have become infected. Anthrax infection can occur primarily through three forms: (a) cutaneous (on the skin); (b) inhalation; and (c), more rarely, gastrointestinal, usually causing distinct clinical symptoms based on its site of entry.[24]

Symptoms of disease vary depending on how it was contracted, but some usually appear within seven days. The way it works is that the toxins are released by the pathogen spread by the body's lymphatic system. In cutaneous anthrax, the most common form, approximately 95% of infections occur when the bacterium enters a cut or abrasion on the skin, such as when handling contaminated wool of infected animals. Skin infection begins as a raised itchy bump that resembles an insect bite, but within one to two days develops into a vesicle, then a malignant pustule, and finally into a painless ulcer, usually 1 - 3 cm in diameter, with a characteristic black necrotic or dying area in the centre. Lymph glands in the adjacent area may swell. About 20% of untreated cases of cutaneous anthrax will result in death, following internal bleeding, tissue damage, and organ failure.[25]

With inhalation (respiratory) anthrax, brought on by inhaling the spores, initial symptoms may resemble a common cold or flu-like symptoms. After several days, the symptoms may progress to severe breathing problems, toxic shock, followed by severe (and often fatal) respiratory collapse. Inhalation anthrax is, again, usually fatal. Anthrax is not known to spread from person to person. In fact, in modern management of the disease, communicability is not

[20] Klemm and Klemm 1959: 458-462; Turnbull 2002: 1-20.
[21] Kenefic *et al.* 2009: e4813.
[22] Kenefic *et al.* 2009: e4813; Van Ert *et al.* 2007: e461.
[23] Dragon *et al.* 2005: 1610-1615.
[24] Lucey 2005: 2486-2488.
[25] Lucey 2005: 2486.

a concern in nursing or visiting with patients with inhalation anthrax. Anthrax also reacts to seasonal change, when variations in temperature, humidity and vegetation favour a rise in incidence in the summer months. Because it is an acute disease, anthrax leaves no skeletal lesions.[26]

Gastroenterological anthrax[27] occurs when the pathogen enters the alimentary tract through the absence of personal hygiene or eating infected meat. It is characterised by serious gastrointestinal difficulty, vomiting of blood, severe diarrhoea, acute inflammation of the intestinal tract, and loss of appetite. Some lesions have been found in the intestines and in the mouth and throat. After the bacterium invades the bowel system, it spreads through the bloodstream throughout the body, making even more toxins on the way, often leading to death. Though anthrax will have had a low-grade endemicity, infecting Indus Civilisation wool workers from time to time, there will also have been epidemics of anthrax, which have affected whole herds and flocks and which would have killed hundreds of animals. This would have severely affected the food and milk supply, but it is likely that, as a result, larger amounts of infected wool would have now been introduced into the industry, so the cycle continues.

It would have been the wool combers and others, i.e. washers and sorters, who handled pre-washed wool[28] who would have been most at risk, and, knowing it or not, would have been carrying out their trade in quite hazardous circumstances. This is not to say that others were immune to risk, similar dangers faced, for example, leather workers, in fact anyone who encounters an infected animal or its products.

Cotton

Cotton (*Gossypium Indicum* Lam.) is a soft, staple fibre that grows in a form known as a boll around the seeds of the cotton plant, a shrub native to tropical and subtropical regions around the world, including South Asia. The fibre is spun into yarn or thread and used to make a soft, breathable textile, which is today the most widely used natural-fibre fabric in clothing.

Evidence suggests that cotton was first cultivated 7000 years ago in the Early Harappan phase. For those who worked with cotton, whose tasks were the drying and preparing of the raw cotton for spinning, many of the risks were the same. We certainly know of the existence of cotton in the Indus Civilisation and the production of it may have been on the same scale as wool. However, cotton processing and cotton garment production would have been significantly large enough to allow for those who worked in the process to develop some ailments that derive from the spores and dust that exist in the cotton fibres.

'Brown Lung' or 'Mill Fever' are 19th- and 20th-century English terms for byssinosis,[29] a chronic respiratory disease, one of the causes of which is the dust of fibres of cotton.[30] It is thought to

[26] Lucey 2005: 2487-2488.
[27] Lucey 2005: 2486-2487.
[28] Barber 1991: 283.
[29] Pickering 2000: 621-631.
[30] The word byssinosis is derived from the Greek word βύσσος, originally meaning fine linen or flax dust. Cotton was unknown to them. Whether the Harappans had linen is debatable, but linseed or flax (*Linum usitatissimum* L.) is recorded from Sanmghol and Shortughai and there is now evidence for the preservation of linen at the site of Tell Abraq (Umm Al-Qaiwain in the modern United Arab Emirates), the centre of what is believed to be Magan, dated to 2100-2000 BC,

result from endotoxins released by bacteria present in cotton dust that cause constriction of the airways and then might lead to fatal emphysema. Over some years, the dust will produce asthma-like symptoms, with narrowing of the airways, especially at the start of the working week, which result in permanent respiratory disability and eventually death.

Traditionally, byssinosis will usually cause wheezing and tightness in the chest, usually on the first day of work after a break. Unlike with asthma, the symptoms tend to diminish after repeated exposure and the chest tightness may disappear by the end of the working week. However, after a person has worked with cotton for many years, the chest tightness may last for two or three workdays, or even the whole week. Prolonged exposure to cotton dust increases the frequency of symptoms, such as coughing and chest tightness, and leads to permanent lung disease that can sometimes be disabling and then fatal. As many as 25% of all those who encounter cotton dust will develop byssinosis in some form.

The extensive use of water in textile production may also have produced some additional risks if the water was prone to not being very fresh and included leeches. We have seen that the industry was not free from disease for those who dealt with the raw wool or cotton, and we can now turn to the dangers inherent in textile manufacturing.[31]

Jute

There is also evidence of the use of jute (*Corchorus capsularis* L.) fibres, presumably for the manufacture of rough textiles, dating to towards the end of the Mature Harappan phase.[32] Once the fibre has been processed into a usable form, the production of jute textiles is much the same as other fibres and then spun into usable yarn in two specific ways before being woven.[33] Like the making of other fibres and turning them into cloth, health hazards were unavoidable. The dust would have led to respiratory diseases, e.g. bronchitis and byssinosis, with the same effects as with cotton workers.

Weaving and Spinning

From what we can perceive from the hand-driven, probably warp-weighted, looms in the period, the weaving process itself was not especially hazardous. The weavers, probably mostly women,[34] operated warp-weighted vertical looms fitted with terracotta loom weights. However, only at Mohenjo-daro is there evidence of spindle whorls and bobbins, and no loom weights have been found. This supports the view that much of textile weaving and carpet making was undertaken as a domestic industry outside, in the villages surrounding the city. However, some high-quality weaving, producing textiles for the overseas markets, may have taken place in the city itself, but there is no archaeological evidence other than a dyeing workshop.[35]

suggesting that the flax may have been grown in the Indus region or even that linen was produced there, see Reade and Potts 1993: 99-106. The effect of flax dust would have been largely the same as cotton dust.

[31] Pickering 2000: 621-631.

[32] Wright *et al.* 2012: 137-143.

[33] Wright *et al.* 2012: 141-142.

[34] Barber 1991: 283.

[35] Barber 1991: 79-125; *Further Excavations*: 416-423; *Ancient Cities*: 128, 159.

It is, of course, possible to imagine an acute injury to the shins or the possibility of losing a finger or injuring a hand during the work. Its principal danger, however, would lie in what long-term or chronic injury the use of the loom may bring in terms of skeletal changes, osteoarthritis, and degenerative changes to the individual. With continual standing, stooping, and all the manual procedures required, many would have suffered from very painful shoulders and backs and have developed severe eyestrain; some may even have developed what we now term 'weavers' cough' with the dust liberated from the looms responsible for an allergy, or even the development of bronchitis. Such problems would have been common were any of the yarns, cotton, or wool to have developed mildew or mould allergens. Whether they used sizing agents in the weaving process, we do not know; if they did, however, it is usual for 20% to come detached during weaving and become a fluffy dust that can be inhaled and become an irritant, consequently with the risk of long-term damage to the individual's respiratory system.

The process of spinning, using terracotta and faience spindle whorls, again while not being particularly dangerous as it stands, the concerns already alluded to about dust and the spores of wool or flax are still relevant, as well as the strain of continual physical activity, particularly to the arms and what this does to the body over decades of activity. The question of eyestrain is even more acute, with the processes requiring more close-up work with the yarns.

One thing that concerns spinning, although it may also be important when considering weaving, is the dangers caused by excessive use of the teeth. Dental attrition, the wearing away of the enamel of the teeth, can often be caused by using teeth to cut yarns, and we have seen occupationally related wear patterns on skeletons where it will inevitably have led in some to severe oral pain and tooth loss. In fact, a detailed investigation by Lukacs and Pastor of worn teeth can reveal a record of past activity patterns, including craft or occupational activities. Studies of the dental samples from Pre-Harappan levels at Mehrgarh and Pre- and Mature phase Harappa yielded evidence of activity-induced dental abrasion, i.e. interproximal tooth grooving and interproximal abrasion patches and lingual abrasion of maxillary incisors in association with rounded wear of lower incisors. This has been determined by the gross size and shape of abrasion features and the orientation of microscopic wear, and ethnographic parallels are employed in inferring causal factors involved in their formation and has led to behavioural activities associated with each type of dental wear. The interproximal grooves among the Neolithic people of Mehrgarh were probably due in part to the production of sinew or fibre in the textile process, and lingual surface abrasion of maxillary anterior teeth is probably due to forceful holding or pulling animal skin between the teeth to soften it.[36]

Both for weavers and spinners, callosities of the hands, especially over the bony prominences of the palm, are common in those who use tools where the hands are subjected to friction and pressure. In fact, every worker, male or female, who uses hands and hand tools, will develop calluses at the point of greatest pressure. In the world of occupational medicine, it has become what is called a 'trade stigmata' and most weavers will have developed them at some point.

[36] Lukacs and Pastor 1988: 377-398.

Figure 9. Dyer's workshop at Mohenjo-daro, VS Area (after *Mohenjo-daro*: pl. LIV(a)).

Dyeing

Room 23 of House II in VS Area at Mohenjo-daro is built from fired bricks set on edge to create a water-tight floor. A small well is located in the southeast corner and circular brick depressions were set into the floor, presumably to hold large pottery vessels. A small drain leads from the well and finely fitted brick floor to a covered drain at the edge of the street. The early excavators at the site suggested that the room might well have been a well-equipped dyer's workshop[37] (Figure 9), but this is speculation as no finds from the room corroborate this view. However, from some of the craft products of the region, such as pottery and terracotta figurines, it is possible to see that the Harappans dyed their cloth several bright colours.

From what the dyes were made can only be speculated; early evidence of the process comes from a piece of cotton, dyed with madder, recovered from Mohenjo-daro. The red to purple dye from the fleshy swollen roots of the madder plant (*Rubia tinctoria* L.) produces one of the most light-fast of natural cotton dyes (and mordants) available.[38] Safflower is a likely candidate to produce yellow dye, as well as saffron, possibly turmeric, and pomegranate.

[37] *Mohenjo-daro*: 216, pl. LIV(a). In Rooms 134-135 of House X in Area HR, three large pottery troughs were found embedded into the floor and secured at the top by circles of bricks around the mouth. They are equal size, 0.79 m in diameter and the same in depth. The space was originally one large room; a partition being added later. It was thought that the troughs were also used for dyeing; *Mohenjo-daro*: 197, pl. LI(c).
[38] *Mohenjo-daro*: 33.

For the colour blue, the prime candidate must be indigotin or indigo. It is a natural dye made with a distinctive blue colour, extracted from the fermented leaves of indigo (*Indigofera tinctoria* L.). There is evidence from Harappa of platforms where the fermenting took place. It was grown as a crop in the Indus Valley, the earliest major centre for its production and processing, and where it was first domesticated. It has a very low order of both acute and chronic toxicity.[39]

Dyeing is defined as the process of colouring fibres, yarns, or fabrics by using a liquid containing colouring matter for imparting a hue to a substance. There are three basic methods of doing this. The first is by staining an item, a temporary means of colouration where the colour is rubbed or soaked into an item without the benefit of a chemical fixative to preserve the colour. The next is the use of pigmentation, wherein the colour is fixed to the surface of an object by another adhesive medium. A true dye is when the colour of a substance is deposited on another substance in an insoluble form from a solution containing the colourant.[40] This process is what is of concern. Natural dyes can be broken down into two categories, substantive and adjective. Substantive or direct dyes become chemically fixed to the fibre without the aid of other chemicals or additives, such as indigo or certain lichens.

Adjective, or mordant dyes, require some sort of substance, usually a metal salt, to prevent the colour from washing or light bleaching-out to darken or sadden the red, blue, green, and purple effect. Most natural dyes are adjective dyes and require the application of a mordant at some point in the dyeing process. Natural dyes, except if involving arsenic, which we know were in use in the Indus region, were not by definition toxic and could do little harm to the dyer. It was the process of using mordants that might have harmed those encountering them.[41]

Some of the raw materials used in dying produce colourfast dyes and we know that the fermentation process for many dyes would have created some physical hazards, if made in sufficient quantities. The vegetable dyes require mordants and are either derived from tannins, readily available from tree bark. Alum (perhaps in combination with lichen), known in the Indus valley, was likely used, as was tin, arsenical copper, and latterly iron, some of which have specific toxic effects. Another important mordant will have been ammonia, whose principal source in the ancient world was either human or animal urine, which can be caustic and very pungent. Alum (alumogenite) or aluminium sulphate[42] and tin sulphate can also be highly poisonous. The use of alum can produce an irritable redness and pain to the skin, burns to the eyes, abdominal pain, and nausea. Alum also must be prepared or 'roasted' and this could also have caused hazards. Over exposure can cause long-term effects, inhibiting learning and causing organ failure.

The evidence from Mohenjo-daro points to the assumption that, unlike spinning and weaving, the dyeing of textiles in the Indus Civilisation may have been semi-industrial. Dyeing produces very strong and unpleasant smells; it is not best carried-out in a confined space. It also requires abundant supplies of water for rinsing and an area for drying. There would have been tubs for water and huge pots for the actual dyeing, channels and running water. The dyeing process

[39] Ferber 1987: 73-83.
[40] Barber 1991: 225-226.
[41] Barber 1991: 225-226.
[42] Barber 1991: 225-226.

would, therefore, very probably not have been carried out in small domestic units, being hazardous, and those involved with it did get ill and some would have died from the process.

One cannot over-emphasise the dangers inherent in textile production in the Indus Civilisation. The workers did not lead easy lives; they would, particularly in urban areas, have employed child labour, many of whom would have succumbed to occupational disease and trauma at a very early age. One neglected aspect is what they did about it all and how did they cope? They will certainly have known about the illness and trauma from which they suffered and it cannot be imagined that they would have neglected to treat themselves in some way. They would not have known about the underlying diseases and their aetiologies, but would have been aware of the symptoms described. Medicines would have existed to treat these symptoms, mostly made from local or imported herbs. However, our textile workers would also have to rely on their gods, both protective and healing, to help them.

Leather Workers

Leather in the Indus Civilisation would have had many different uses, from water carriers, bags, harnesses for animals, as well as boots and sandals. Leather workers faced many of the same risks and hazards as did textile workers, i.e. those who prepared the hides for tanning, knowing it or not, carrying out their trade in quite hazardous circumstances, as they encountered dead cattle, potentially infected with cutaneous anthrax. Exclusive to leather workers was the tanning process, which would have been considered a highly noxious and smelly trade and relegated to the outskirts of towns and cities. In fact, tanning is so foul smelling, that tanneries are still isolated from towns today, many in South Asia, where such primitive methods are still used. As to its origins, we know that tanning was being carried out as early as the Pre-Harappan by the inhabitants of Mehrgarh, certainly by the Mehrgarh IIA-B periods.

Hides or skins typically arrived at the tannery dried stiff, and dirty with soil, blood, and excrement. First, the tanners would soak the skins in water to clean and soften them. Then they would pound and scour the skin to remove any remaining flesh and fat. Next, the tanner needed to remove the hair fibres from the skin. This was done by either soaking the skin in human or animal urine, painting it with an alkaline lime mixture, or simply letting the skin putrefy for several months, then dipping it in a salt solution. They may even have used the animal's brains, which would have been mixed with warm water and then mashed up into a paste. They would then rub the mixture into the stretched hide until it was thoroughly saturated and soaked in. After the hair fibres were loosened, the tanners scraped them off with a knife. Once the hair was removed, the tanners would bate the material by pounding dung into the skin, or soak the skin in a solution of animal brains. The kinds of dung commonly used would have included that of dogs and pigeons. Sometimes the dung was mixed with water in a large vat and the prepared skins were kneaded in the dung water until they became supple, but not too soft. The ancient tanner might use his bare feet to knead the skins in the dung water and the kneading could last two or three hours.

It was this combination of urine, animal excrement, and putrefying flesh that made ancient tanneries such unhealthy places in which to work. It is also possible to conjecture that some, including children, were employed as dung gatherers. In the location of the tanneries, it was

likely that there were pots located on some street corners where human and animal urine could be collected for use in tanneries. In some variations of the process, cedar oil, alum, or tannin was applied to the skin as a tanning agent. As the hide was stretched, it would lose moisture and absorb the agent.

It is not difficult to understand the risks and hazards to the health of Indus Civilisation tanners. Above all, it is a dirty trade and there would have been the minimum personal hygiene, like continual hand washing, thus contributing to eye, skin, and gastrointestinal diseases. The use of animal excrement and cattle urine would have placed the tanners at risk of contracting leptospirosis or Weil's disease, never mind the hazards of the ammonia content. As we have already seen, the use of alum (aluminium sulphate) can also be hazardous, as the chemical substance was presumably obtained in a state of high purity. Alum dust inhalation may irritate the respiratory tract and is known to cause skin irritation, especially under repeated or prolonged contact, or when moisture is present. It may also irritate the gastrointestinal tract, causing nausea, vomiting and purging. Of other risks, given the ways in which pulmonary tuberculosis can be contracted, leather workers would also not have been exempt from these risks.

Metal Workers

Evidence now points to only the melting of copper taking place within the Indus homeland. It possesses no major metal deposits and there seems to be no evidence for the smelting of metal ores at any of the Indus Civilisation sites. This is proven by the lack of evidence of smelting by way of slag and the conspicuous accumulation of other debris and broken firing structures, such as vitrified masses or silica and other fused minerals that usually accrue in mounds near the smelting furnaces. It seems that post-smelted metal ingots were imported into the Indus region and copper ingots have been found at several sites, as well as a possible lead ingot at Mohenjo-daro. It seems likely that the smelting, mostly of copper, was undertaken where the metal ore was sourced outside the Indus Civilisation homeland in Rajasthan, Baluchistan, Afghanistan, and possibly the Gulf.[43]

Smelters and Handlers

For smelters, located at the source of the ores, the occupational hazards of their work were many, from the crushing and sorting of the ore to the likelihood of serious or minor traumatic injury, particularly to the limbs, torso and eyes, from the heat and sparks of their single-use furnaces. One other factor is the clinical toxicity of the smelting operation itself and its inherent dangers to the workforce. The handling of oxidised copper and the smelting process can also produce toxic effects if the ore is prone to having a high arsenic content.

From the very beginnings of metallurgy in the Pre-Harappan phase, when smelting would have been undertaken locally, growing demand for metals for agriculture, craft industries and possibly combat would have necessitated taking risks, and poor and hazardous working conditions would have been accepted as a norm. In the early stages, chronic exposure to arsenic, and for other metal workers exposure particularly to lead, would not have been

[43] Hoffman and Miller 2009: 240-243.

recognised as an occupational hazard, particularly in view of the shorter life spans of the time through disease and accidents. Later, that the process brought on signs of illness may well have begun to be understood, as anyone smelting copper with even modest arsenic content under primitive conditions, or without strict personal hygiene, or in an indoor setting, would run the risk of being poisoned.[44] That this knowledge, however, would have led to the introduction of controls to limit the risk is unlikely.

The process of handling the ores, undertaking the smelting process and the proximity to the furnaces, suggest that at least some of the workmen may have, over a period, become susceptible to low-grade chronic arsenic poisoning. In this case, ingestion would be the most likely mechanism, since the location of the smelting operation, high on the hill, allowed for maximum ventilation.

The effects from which the smelters would have suffered likely included skin changes, hair loss, lesions on palms of the hand and soles of the feet, respiratory inflammation and particularly gastrointestinal problems. Occasionally it would involve vascular wall injury and neurological complications.[45] Other than dyspepsia, also common would have been headaches, drowsiness, confusion, and sometimes convulsions. Of course, not all the workers will have become affected by arsenic poisoning. Some may not have come directly into contact with the ores or the finished product. For those affected, however, the condition of the skin and their consequent external appearance may have been quite shocking for the local population and they may have lived like 'lepers' in their own community, having very little contact with them.

Arsenic

One of the major threats to the health of copper smelters was the threat of low-grade arsenic poisoning from the ores. During the process of copper smelting, arsenic passes from the solid to the volatile state and leaves the smelting furnace in the form of localised toxic dusts. Arsenic is an extremely toxic heavy metal and long exposure to low-dose arsenic can result in chronic ill health for many who encountered it. In fact, the levels of arsenic in copper ores do not have to be particularly high to produce serious toxic effects. Ingestion, perhaps from licking fingers, inhalation of dust, outdoor inhalation, and skin absorption, even in small amounts and occurring together, would allow for toxic effects; arsenic content of the ores as low as 4%-5% could produce severe problems for the smelters. The most common condition would have been dyspepsia, produced by ingestion of low levels of arsenic and would have been especially serious if there were existing lesions of the digestive tract, such as ulcers. Another hazard may have been brought about by the handling of re-used water, used for cooling the furnaces, which after time may have built-up a concentration of arsenic. Copper ore if it contains as much as 4%-5% natural arsenic can cause a toxic effect and if there is sufficient exposure can create circumstances where the user will start to develop low-grade chronic arsenic poisoning, with attendant skin and stomach problems, hair loss, and other symptoms. A common feature of all this exposure would have been the lack of personal hygiene; continual hand washing was not always an option and hence absorption by the skin, contact with the eyes, and ingestion would have occurred.

[44] 44 Harper 1987: 652-656; Arnott 2008: 108-120.
[45] Harbison 1998: 30-31.

Arsenic, usually in the form of arsenic trioxide (As_2O_3), occurs naturally as a steel-grey metal that is insoluble in water. It is often present as an impurity in several other metal ores and is generally produced as a by-product in the smelting of these ores, particularly copper.[46] Arsenic has a boiling point of 616°C, which can lead to losses into the atmosphere of highly toxic arsenic oxide fumes. Inorganic arsenic is released into the environment from several anthropogenic sources, which include primary copper smelting, and a high exposure to arsenic fumes and dust may occur during this process.[47] The entry into the body tends to be through both inhalation of fumes and, more significantly, the ingestion of dust and fumes, the latter the most likely scenario for the copper smelters.

After ingestion, the metal is widely distributed in the body by blood, bound to globin in haemoglobin. Almost all the arsenic is excreted in urine and to a lesser extent in bile, skin, and faeces; any toxic traces that remain will then react with the body's metabolism. With several different compounds and methods of exposure to arsenic, the toxicity varies from organ to organ. Chronic arsenic poisoning has also been associated with adverse effects to the skin, respiratory tract, central nervous system, liver, cardiovascular system and the haematopoietic system. The skin and respiratory tract are most notably the sites of arsenic-induced neoplasms.[48]

Arsenic is particularly harmful to the skin and prolonged handling would have resulted in a local hyperaemia and later vesicular or pustular eruptions; moist mucous membranes are most sensitive to the irritant action. Conjunctiva, moist and macerated areas of the skin, eyelids, and the angles of the ears, nose, mouth, and respiratory mucosa are also vulnerable to the irritant effects. The wrists become susceptible to dermatitis, as do the genitals, if personal hygiene is poor.[49] Perforations of the nasal septum may occur. Arsenic can produce skin sensitisation and contact dermatitis, and can also produce keratoses, especially of the palms of the hand and soles of the feet.[50] As arsenic has a predilection for the skin too, it is also concentrated in the nails and the hair.[51]

Airborne arsenic particles can be deposited in airways, but absorption into the blood from the lungs is dependent upon particle size and chemical form. The ingestion of arsenic can also be a concomitant of the inhaled form from swallowed sputum and unhygienic eating habits.[52] Symptoms include weakness, loss of appetite, nausea, followed by secondary and tertiary complications such as conjunctivitis and a series of nasal and respiratory problems, the perforation of the nasal septum, together with the skin complaints, described above, are usually the most common.

The final stages usually are neurological, as chronic exposure to inorganic arsenic compounds may lead to neurotoxicity of both the peripheral and central nervous systems, starting usually with sensory change, paresthesia, and muscle tenderness, followed closely by weakness

[46] Sittig 1991: 157-158.
[47] Klaassen 2001: 818-820.
[48] Harbison 1998: 30; Dart 1991: 818-823.
[49] Sittig 1991: 158; Holmquist 1951: 1-21.
[50] Sittig 1991: 158.
[51] Harbison 1998: 30; Lundgren *et al.* 1951: 1556-1560.
[52] Sittig 1991: 159.

and progressing from proximal to distal muscle groups.[53] Peripheral neuropathy may be progressive, involving both sensory and motor neurones involving demyelination of long axon nerve fibres. Chronic occupational exposures produce more gradual, insidious effects, which may occur over a period of years. Liver injury, characteristic of long-term chronic exposure, manifests itself mainly in jaundice and may progress to cirrhosis and ascites. In contrast to most other human carcinogens, it has been very difficult to confirm the carcinogenicity of arsenic. Over time, vascular wall injury with clot formation is also common.[54]

Copper smelters could not even have hoped to escape the effects of arsenic on their health from their occupation. How many and over how many years they would have suffered, it is impossible to guess; perhaps the operation was seasonal, but this would not relieve them for most of their working year from the exposure to low-dose arsenic, with the resultant chronic ill-health and the need to treat the symptoms in some way. The symptoms brought about by constant contact with arsenic would soon have become noticeable, even in the early stages of the disease, especially the skin conditions and the chronic gastrointestinal problems, brought on by ingesting arsenic particles. They would, over time however, developed some tolerance to exposure to arsenic, which after prolonged exposure to sublethal levels, the acute effects would diminish in their severity. The chronic effects and the carcinogenicity would not.

It is unlikely that the smelters themselves had any knowledge of the occupational health dangers of their work. They may well have understood that their work made them ill, but they would have had had no understanding of why and how; and clearly they are unlikely to have had any employment alternative. Nevertheless, they would certainly have been fully aware of the symptoms and perhaps have come to terms with them, for, as we shall see, they attempted to treat them, perhaps successfully in some circumstances.

The eventual outcome would certainly have been a higher than usual mortality rate and if we knew where the copper smelters lived and where they buried their dead, then we could begin to answer the question of the extent of the poisoning, as arsenic is laid down in bone and teeth, which can be measured by forensic pathology.[55] Arsenic poisoning does not, however, leave any characteristic skeletal lesions.[56] However, a method for analysis of skeletal remains for arsenic using inductively-coupled plasma mass spectrometry (ICP-MS) has been developed, with the potential to identify individuals, groups and communities engaged in smelting arsenic-rich copper ores,[57] although some doubt its usefulness as bone tends to absorb trace elements with which it comes into contact.

That the smelters were likely from a local and not an advanced culture, trading with the Indus Civilisation, does not diminish in any way the scenario of their suffering and their association with the Indus Civilisation. There is evidence from copper objects found in Mature Harappan levels at Mohenjo-daro of arsenic contents as high as 4.43%, thus supporting the hypothesis of copper smelters being susceptible to low-grade chronic arsenic poisoning.[58]

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[53] Klaassen 2001: 819-820.
[54] Klaassen 2001: 820.
[55] Harper 1987: 652.
[56] *Human Paleopathology*: 328.
[57] Oakberg *et al.* 2000: 895-901.
[58] Shrivastva 1999b: 173-180. An analysis of the arsenic content of bronze and copper objects from Harappa has shown a needle (11859) with an arsenic content of 2.96% (see Blakiston 1937: 87-90). The concentration of arsenic

Other Hazards and Injuries

Metal workers, including those within the Indus Civilisation homeland, must have experienced other hazards associated with their occupation. The way the furnaces were constructed would have led to hazards associated with exposure to carbon monoxide and from 'metal fume fever' from the fumes. Both resemble each other in their subacute form, like a serious infection with influenza. In both instances, the strength of the prevailing wind would mitigate the hazards, but they could be quite severe during calm periods, even out of doors.

There would have been instances of fractures and soft tissue trauma, but one of the most common would have been burns and other injuries brought on by the handling the contents of the furnaces. Additional hazards included the burning of charcoal and the transportation of the ores to the smelting site. Also, it would have been almost impossible for any of the metalworkers that encountered the smelting process to avoid serious burns. We have no knowledge of the nature of any burns or the treatment, other than what we can conjecture from the contents of one of the pottery vessels found in the shelter. Some of the smelting processes could also be hazardous to the eyes, especially sparks, not to mention any number of eye conditions that can be caused by the absence of personal hygiene. Remedies are likely to have been readily available as a poultice, using locally grown or wild plants. Honey, a natural remedy for burns and an effective antiseptic, may well have been added afterwards as it does not require heating or infusing during a cooking process.

There must have been some form of personal protection against the heat, embers, flying debris, and the occasional exploding furnace. This protection is likely to have taken the form of hide aprons and gauntlets, probably manufactured locally. It is also possible that they used some sort of eye protection. Ideas of semi-naked and exposed figures attending the furnaces are quite implausible. As they tended the furnaces to ensure that they stayed alight and pumped the bellows, they would have had a quite a close proximity to the furnaces themselves, eye injuries, therefore, would have been a serious and frequent risk; perhaps they wore primitive goggles with slits held in place with leather thongs, which would have provided some protection against flying embers, explosion debris, and even infrared light, although they could not do a great deal against the smelters contracting cataracts. The constraints to vision might not have had a limiting factor, as the furnaces would have been red hot and thus closely visible.

Copper smelters would have begun to feel the effects of chronic arsenic poisoning soon after starting to work in the occupation, perhaps some at a very young age. Though they would have had no idea of the aetiology of the underlying condition, the evidence clearly points to

in the needle is high enough to produce some illness in the smelters who produced it. Ratnagar (*Trading Encounters*: 119-123), has reviewed the copper sources of the Harappans and notes that arsenic is a natural impurity in some copper ores. Sulphuric ores that contain arsenic lose much of their volatile arsenic oxide when roasted; but oxidic ores containing arsenic, if smelted under reducing conditions, retain an appreciable arsenic content, as much as 7% (see also Agrawal *et al.* 1981: 9-16). From the site of Bagasra in the Gujerat, dated to Phase III (late Mature Harappan) come two objects, a bangle (BSR 6310) and a ring (BSR 4494), which, according to the analysis using the Energy Dispensive X-ray (EDAX) method, showed arsenic content of 0.44% and 0.25% respectively. Locally, arsenic is a common constituent of many copper ores (e.g. energite and famitinite) and passes it on to the metal unless it is roasted for a long period of time at a temperature higher than 500°C; see Patel and Ajithprasad 2015: 219-231. However, in the copper ores, the percentage of arsenic will be higher. Analysis of some objects from the site of Khetri in Rajasthan, located by the copper mines, showed 4.28% arsenic content; see Hegde 1961: 225-228.

them having sufficient knowledge of remedies handed down from generation to generation, to be able to treat, if only in some small way, the symptoms and other ill-effects of their occupation; they would have needed to continue making and administering their primitive medicines on a regular basis.

Mining and Metalworking in the Indus Civilisation

The earliest evidence of the use of copper from the Indus Valley comes from Neolithic Mehrgarh, where a pure copper bead has been found in a Mehrgarh IB phase context. After this time copper came into common use, right through to the Late Harappan Phase, as was the use of tin (for making bronze) gold, silver, lead, and antimony. They used these metals for any number of purposes – including tools, utensils, weapons, and body ornamentation. At Harappa, a large hoard of well-preserved copper and bronze objects of everyday use has been discovered, which epitomises their importance.

Melting, Alloying and Metal Processing

The metalwork that occurred in the Indus Civilisation homeland was centred around melting and alloying of already smelted ingots, of mostly pure copper and tin, to produce secondary or refined ingots, which is a common intermediary stage between the original smelting process and the final fabricated or cast object; this was also for ease in transportation for traders. The process of melting also created the opportunity for alloying, particularly copper with tin and other alloys. Like smelting, the process had its own hazards, many of which they shared with the smelters, such as the handling of molten metal, potential poisoning by arsenic, heat, and the dangers from the furnaces in use.

There is evidence from Lothal for furnaces used for melting copper ingots in terracotta bowls. It was a simple and circular brick structure (0.8 m in diameter and 0.6 m deep) with mud plaster on the inner face, which was vitrified owing to the intense heat generated. Two types of these furnaces were used: circular and rectangular. The long mouth of the furnace suggests that bellows were used to increase the temperature.[59] This was also a dangerous process.

The final process would be casting and fabrication. Casting refers to the manipulation of molten metal or casting, and fabrication is the treatment of non-molten metal, whether cold or hot, and involves the direct shaping of metal, whereas casting begins with the shaping of other materials into which the molten metal is poured. The tools used in both techniques overlap to some degree, and it is likely that the same workshops undertook both processes. The possible division of manufacturing stages into discrete and often exclusive activities practised by different craftsmen is an important part of metal working.[60]

What we cannot neglect is the hazards that existed for those who re-melted cast copper, an intermediary stage between production of the smelted ingot and the production of the final object, after the smelting process[61] and alloying of bronze, or those craftsmen who fabricated or cast it into the tools, weapons and cooking utensils known to us from excavations. The

[59] Shrivastva 1999a: 33-46. For the Lothal furnaces, see *Lothal:* 22.
[60] Hoffman and Miller 2009: 240-243.
[61] Rao 1987: 385-386; Hoffman and Miller 2009: 247-249.

hazards to those facing smelters were similar (heat, sparks, exploding furnaces and crucibles, fume inhalation), confirmed by what we know of the nature of the furnaces used for re-melting.[62] In the metal workshops as well, extended exposure to low-dose arsenic and lead allows the substances to be absorbed and laid-down in bone, hair, teeth, and nails, with resultant chronic ill-health.

The cupellation of lead and silver, i.e. the purifying and refining processes, would also have been hazardous and may have been the cause of some toxic poisoning. Lead was particularly dangerous, and poisoning by it is to be regarded as one of the earliest occupational diseases of humans. It seems that many lead miners would have suffered acute or chronic 'plumbism' or lead poisoning, although it depended upon the type of the ore, the personal hygiene of the worker, and other physical factors. For example, the low instance of lead poisoning amongst those who work galena ores is related to the insolubility of lead sulphide in the tissue fluids of the lungs. Galena, the silver and lead ore, however, is itself non-toxic, but instances of the disease in 'dirty' galena mines and in miners with poor hygiene is possible. These miners handled lead, inhaled particles of it, and probably had some of it mingled in with their food. For those who worked in lead smelting and cupellation, the high-level exposure to lead fumes would also have led to the disease.[63]

Mining

The copper mines that served the Indus Civilisation, produced native copper, sulphides (chalcopyrite or copper pyrite), copper oxide (cuprite), carbonates (malachite), and sulcate (chrysicolla). Actual archaeological evidence of mining and metal working is quite scanty and we do not know a great deal about their methods, although it is believed that some of the copper was mined in Rajasthan (probably the Khetri mines), and even Afghanistan, and then smelted *in situ*, with the workable ingots transported the great distances to the Indus Civilisation heartlands (although other sites are mentioned, including the possibility of some ores being imported from the Gulf).[64] There are also huge hazards of mining accidents and lung diseases. The symptoms of occupational lung diseases would have existed, e.g. silicosis, the filling of lungs with dust, which obstructs breathing and can take up to ten years to present; by the time the symptoms manifest themselves, they are already deadly. Lead was sourced in north-east Afghanistan in its natural pre-smelted form from alluvial deposits of cassiterite and then smelted and taken to the Indus Civilisation heartland for local use or for re-exportation westwards as tin ingots.

Bead Makers

There are two major processes associated with beadmaking: the manufacture of the beads themselves, followed by bead perforation, which are both highly skilled and intricate processes.[65] Beadmaking started at least by the Early Harappan phase, where there is

[62] Rao 1987: 385-386.
[63] Nriagu 1984: 309-312. There is not a great deal of evidence of the use of lead. Its presence in many of the copper objects from Mohenjo-daro is of note; copper ores associated with lead occur in both Afghanistan and Baluchistan and may be indicative of the small amount of imported into the Harappan heartland; see *Mohenjo-daro*: 483.
[64] *Mohenjo-daro*: 483.
[65] Bhan *et al.* 1994: 141-157; Kenoyer 1997: 266-274. An account has been published of contemporary agate beadmaking at Khambhat in the Gujarat which uses many of the original process unchanged for thousands of years and emphasises

evidence for two major types of stone bead manufacture, i.e. hard stone beads made from carnelian, agate, jasper, and lapis lazuli, and soft stone beads made from steatite (also known as soapstone or talcose). The difference between the two processes, from the procurement of the raw materials to the final distribution of finished beads, is important to an understanding of their relative value and how the manufacturing process was organised,[66] including the management of the workforce and the risks they both faced.

As an example, agate beads only achieve added value after chapping, sawing, grinding, drilling, and polishing, many of the stages accompanied by heating in kilns. Steatite beads must first be hardened in high-temperature kilns. The finished steatite beads were then hardened and whitened by glazing and firing at high temperatures; some of the long cylindrical beads were decorated with a blue-green glaze. This glaze was probably made with powdered frit (a mixture of silica and fluxes) and copper oxide (Cu_20), combined with a flux from plant ash (*sajji*), a process that is well documented for glazed faience. The temperatures needed to harden the steatite range from 900-1000°C, and by using a flux the glaze can be produced at around 940°C.[67] Studies of the saw marks on the Early Harappan manufacturing waste from Harappa provide some new information on the earliest metal saws used at the site. These early saws left non-parallel sawing striae with rounded edges that may be the result of unskilled sawing, or a badly made saw. No samples of early saws have been recovered but the saw marks point to a relatively unrefined form of saw. In contrast, sawn steatite manufacturing waste recovered from Mature Harappan levels at Harappa reveal the use of a more refined and standardised type of saw.[68]

Considerable evidence for carnelian, agate, and steatite bead making has been recovered from various locations in Harappa dating to the Mature Harappan phase. Both technologies developed side by side at Harappa, but the organisation of production stages and the varying uses of pyrotechnology, drilling techniques, and finishing are quite distinct. As in the Early Harappan phase, agate beads were generally produced by several stages of heating in simple pit kilns, flaking, grinding, drilling, and polishing. One of the most hazardous processes of agate and carnelian bead manufacture would have been the chipping, where the process involved the flaking or knapping of the raw materials with a small copper stake. Steatite beads, on the other hand, were made by sawing, drilling, fine grinding, glazing, and heating in kilns to harden the raw material and colour them white or blue green.[69]

From Mound ET at Harappa, steatite working has been identified in a restricted area inside the city wall and associated with numerous other crafts used to produce items for elite consumption and trade. These crafts include agate and other stone bead making, shell working, bone and ivory carving, and chert weight manufacture. Chert tool manufacture and use is quite common in this area and may have been associated with wood-working and furniture inlay setting. There are also some indications of copper tool and ornament production, gold

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the risks and hazards that beadmakers face, particularly in the heating, chipping with copper stakes, sawing, grinding, and drilling; see Kenoyer *et al.* 1991: 44-63. A detailed discussion of bead making, shell working, and faience making has been produced, but it only discusses the manufacturing process; like the other papers above, there is no attempt to understand its risks and toxicity (see Bhan 2013: 773-794).

[66] Kenoyer 1997: 267.

[67] Kenoyer 1994: 71-80.

[68] Kenoyer 1997: 266-274.

[69] Kenoyer 1997: 266-274.

ornament making, and faience production. Specialised ceramic vessels coated with what appears to be steatite powder may be associated with the firing of steatite beads or faience objects.[70]

Perforation of stone beads by pecking or drilling would have been undertaken using a bow drill, but it is possible that a more advanced drilling apparatus was used for perforating the elongated carnelian beads. Perforations were usually achieved by working from both ends and joining the hole at the centre of the bead. Short, biconical-shaped beads of carnelian and agate reveal the use of a pecking technique that results in a rough hour-glass-shaped perforation. Copper drills appear to have been used to perforate soft stone, such as steatite. So far there is no concrete evidence for the use of solid copper drills with abrasive, but we now know of the use of tubular drilling, presumably with a thin copper tube and a fine abrasive.[71] These drills are likely to have had a slit along one side to allow the addition of the abrasive slurry. Tubular drilling was already known to have been used at Harappa for the perforation of large ring-stones and for decorating large stone objects, but until now it has never been documented for small agate beads. The tubular drilling technique may have begun during the late phase of the Mature Harappan Phase and it is well represented during the Late Harappan occupation.[72]

Some of these drills may have been used to perforate unfired steatite bead blanks, but most were probably used on shell, ivory, or wood. Some of the tapered drills made of chert or jasper blades were modified into a more specialised form, referred to as a tapered cylindrical drill. These drills were used to decorate and perforate softer stone (lapis lazuli, turquoise, limestone) and to perforate short beads of harder stone (agate, carnelian).[73]

Constricted cylindrical drills have only been reported from Indus Civilisation sites during the Mature Harappan phase and represent an important technological innovation. They have a long, cylindrical shape that is wide at the tip and constricted in the mid-section. This shape was developed by the Indus Civilisation artisans to facilitate the drilling of long, slender beads of hard stone, e.g. carnelian, agate, jasper, and bloodstone. In contrast with the tapered drills, this type of drill is made from a specific raw material which is harder than most bead materials and can efficiently perforate carnelian and agate.[74] In 1996, a red-brown glass bead was found at Harappa among a hoard of beads in a room dating to *c.* 1730 BC (Late Harappan).[75] Being the earliest glass bead from the Indus valley, this tiny object may in fact represent the beginning of local glass production.

The hazards and risks that beadmakers would have had to face were varied. The chipping would have produced small amounts of flying debris that could have injured eyes and skin. The drilling and sawing would have produced dust, which is a hazard to the eyes if no protection is worn; if inhaled, the dust can lead to lung disease, i.e. silicosis. The heating of agate, carnelian,

[70] Kenoyer 1997: 266-274.
[71] Meadow *et al.* (Harappa Excavations 1996, unpublished report submitted to the Department of Archaeology, Pakistan Government).
[72] Kenoyer 1997: 266-274.
[73] Kenoyer and Vidale 1992: 495-518.
[74] Kenoyer 1997: 266-274.
[75] Meadow *et al.* (Harappa Excavations 1996, unpublished report submitted to the Department of Archaeology, Pakistan Government).

and steatite beads has its own hazards, causing burns to the hands and face, and the kilns they used would have had a propensity to the occasional explosion. The greatest risk would have been with the toxicity of some of the materials, especially the flux and the copper oxide. For example, excessive use of copper oxide can cause skin irritation and can then lead to dermatitis.

As a comparison, tools and techniques of beadmaking on Minoan Crete are described by Don Evely, who supplements his account with fuller evidence from Iran and India.[76] This study has looked at the evidence from both prehistoric Indian sites and the surviving Indian bead industry of Khambhat in Gujarat to discuss the relevance of modern ethnographic accounts for the interpretation of archaeological data, such as location and layout of workspace and to raise fundamental questions about craft specialisation and evidence for state control.[77]

Seal Carvers

Seal carvers faced many of the same risks and hazards as beadmakers, including the firing of seals made from clay, steatite, and other materials. An analysis of work marks on unfinished seals from the Mature Harappan phase, suggests that the craftsmen used a range of specialised tools, e.g. fine, denticulated copper or copper alloy saws, stone and metal finishing tools, stone/metal drills, and various grades of grinding stones, ranging from course to fine.[78] The use of these tools, especially the grinding stones, if used without eye protection, creates certain basic risks to the user.

With seal carvers, there is also one additional risk. A basic hazard to those engaged in minute seal carving would have been damage to eyesight. Seals were carved without the assistance of magnifying glasses, and constant eye strain and the deterioration or eventual loss of eyesight were distinct possibilities. Symptoms would have included headaches, sore eyes or eye fatigue, eye irritation, blurred vision, double vision, and neck, shoulder and back pain. The result would have been an inability of focus properly at near-working distances for any periods of time. Leonard Gorelick and John Gwinnett have discussed the methods in the ancient world by which minute carving could be undertaken before the discovery of the magnifying glass. Their hypothesis is that such close work was undertaken by craftsmen, who, due to their existing myopia, had excellent close vision and the capacity to see objects up close.[79]

Sewer Cleaners

Wherever a drain had to traverse a longer distance, or where several drains met, a cesspool was installed, this being the simplest method to avoid clogging, by allowing solids to settle. The effluent flowed into the brick shaft at a high level, filled it, and flowed out the other side at a slightly lower level. The suspended matter gradually formed a deposit which had to be removed via steps leading down into the pit. These cesspools were also probably covered over with wooden planks and regularly cleaned. The offensive smells emitted by the sewage chutes, soak pits, cesspools, and sewers must have been a considerable public nuisance, which

[76] Evely 1979: 202.
[77] Kenoyer *et al.* 1991: 44-63; see also Roux 1995: 39-50; Eyre 1987: 167-221; Possehl 1981: 39-47.
[78] Meadow and Kenoyer 2010: lii, n.9.
[79] Gorelick and Gwinnett 1981: 27-34.

could only have been relieved by frequent cleaning, which would have required a great deal of manpower to both achieve and maintain, and there will have been dedicated sewer cleaners at Mohenjo-daro and probably elsewhere.

In the case of the Indus Civilisation cities, the sewage carried by the drains was mainly water containing excrement, and a major source of harmful micro-organisms, including bacteria, viruses, and parasites. Exposure to sewers may also have resulted in a number of illnesses, including: (a) gastroenteritis, characterised by cramping stomach pains, diarrhoea and vomiting; (b) Leptospirosis or Weil's disease, a flu-like illness with persistent and severe headache, transmitted by rat urine, where damage to liver, kidneys, and blood may occur and the condition can often be fatal; (c) Hepatitis B and C, characterised by inflammation of the liver and jaundice; (d) occupational asthma, resulting in attacks of breathlessness, chest tightness, and wheezing, produced by the inhalation of living or dead organisms; (e) infection of skin or eyes; and (f) increased parasitic infections, e.g. *Endamoeba histolytica*, *Ascaris lumbricoides* and *Trichurus trichiura*. It would have been difficult for sewer cleaners to avoid exposure to such hazards.

We know that the most common way for organisms to enter the body is through hand-to-mouth contact during eating and drinking, or by wiping the face with contaminated hands, or by licking splashes from the skin. Another method is by skin contact, through cuts, scratches, or penetrating wounds. Certain organisms can enter the body through the surfaces of the eyes, nose and mouth, such as breathing in organisms, perhaps as dust or mist. Other hazards will have included exposure to toxic gases, such as methane and hydrogen sulphide.

Sewer workers, were no doubt, used to unpleasant smells although many will have developed subacute symptoms including sore throat, cough, chest tightness, breathlessness and thirst; a high prevalence of respiratory symptoms is associated with an exposure to sewage. Other health hazards include cardiovascular degeneration, musculoskeletal disorders (i.e. osteoarthritic changes, intervertebral disc herniation), dermatological problems, as well as trauma from climbing, crawling, and other activities associated with their occupation. Like other groups of workers, they are likely to have known about the symptoms of the diseases from which they suffered and may well have prepared primitive, and perhaps not so primitive, medicines to treat them.

Ratnagar in her interpretive study of Indus Civilisation archaeology discusses whether sewer cleaners were in fact a specialist class of labourers, an under-class, the lowest echelons of society, and whether they were the precursors of part of an early caste system that fully developed in the historic periods. In rejecting this notion, she is of the belief that we cannot ascribe to the Indus Civilisation a misconceived notion of traditional India and that the marginalised and landless poor did the work of cleaning the drains not because of this relationship with society, but perhaps because of compulsory labour.[80]

[80] Ratnagar 2016: 86-88.

Builders, Carpenters and Bricklayers

Indus Civilisation building workers would have been subjected to many hazards and industrial diseases.[81] These would have included high levels of traumatic injury, musculo-skeletal disorders, respiratory disease, skin disease, hearing loss, and possibly cancer. Specific hazards would have included: (a) eye disease,[82] such as trachoma, which is an inflammation of the conjunctiva on the front of the eye, as well as possible dehydration of the cornea from high temperatures and lack of humidity, both of which can cause blindness. They would also have been exposed to possible eye trauma; (b) the effects of musculo-skeletal disorders and skeletal arthropathies, particularly osteoarthritis.[83] This can stem from repetitive movements, awkward positioning, or the bearing of heavy loads; (c) traumatic accidents,[84] which can occur from working in close proximity to other building workers who may be using heavy and sharp tools and working from a considerable height above ground; and (d) respiratory disease,[85] damage to the lungs by inhalation of dust, which may in the short term result in asthma, but long-term exposure may result in pneumoconiosis and silicosis, the latter being brought on by the inhalation of crystalline silica. Inhalation of larger particles, such as sawdust in the case of carpenters, is thought to produce an increased risk of nasal cancer.

Many urban centres or cities, particularly Mohenjo-daro, make use of fired bricks and would have used a bricklayer skilled in building techniques, and very precise work such as the construction of well shafts. Bricklayers were likely exposed to loads, repetitive force exertions of the upper extremities, frequent bending, and working with the arms in an elevated position. Other dangers include dust and quartz exposure. Bricklayers were at increased risk of low back pain, complaints of pain in arms and legs (which would likely to be reflected as skeletal stress markers), and being injured, particularly if working at heights or lining wells.

Working in this industry in the Indus Civilisation, like in most ancient societies, was not safe. What we do not know is what was being done to support these workers in attempting to alleviate the illnesses and conditions caused by their work. We do not know if a healer was available to them, but those who worked in the building industry are likely to have fended for themselves.

Herders

Indus Civilisation cattle herders faced several infinitely varied risks and hazards. These fall into two categories, the ability, because of very close proximity to their animals, of contracting

[81] Though separated by 1000 years, the clearest graphic descriptions of buildings workers in the ancient world are of the Egyptian labourers illustrated within the 19th-Dynasty (1295-1186 BC) Tomb of Ipwy (TT21) at Deir el-Medina, on the west bank of the Nile, near the Valley of the Kings. Ipwy was the chief sculptor, one of the team who built the royal tombs in the Valley of the Kings during the earlier years of the reign of Ramesses II. There are two painted scenes within the tomb that depict builders and building craftsmen; see Davies 1927: 63-70, pls. xxxvi-xxxvii. Focusing on the catafalque and naos scenes, it is possible to determine instances of industrial injury and specific hazards at work, which helps lead to an understanding of the occupational health of such craftsmen. The instances of industrial injury and diseases of building workers are unlikely to have been any different for the Indus Civilisation, where we have monumental buildings, such as those at Mohenjo-daro.

[82] Vinger and Sliney 1995: 507-518.

[83] Ringen *et al.* 1995: 690-694.

[84] Ringen *et al.* 1995: 885-901.

[85] Balmer and Scannell 1997: 305-327.

a zoonotic disease; and trauma associated with their work, i.e. being injured by their animals, from protecting their herds from wild animals, and possibly rustlers.

Various diseases are known to be associated with pastoralism and animal husbandry, and the expansion of agriculture to new environments and the domestication of animals brought the potential of contracting animal-borne diseases or zoonoses. One such way was through the fouling of drinking water by animal waste. These untreated animal wastes, also scattered on cultivated land, also maximised the potential for parasitic worms. As we have already seen, the most hazardous risks were tuberculosis, brucellosis, tetanus (see Chapter 3), and other infections, as well as infectious and parasitic diseases caused by poor sanitation and personal hygiene.

The most dangerous animal for them, without doubt, was the bull – immensely strong and unpredictable. Often docile for months on end, suddenly, for no apparent reason he might turn on a herder and gore or crush him with savagery. Whether it was possible to keep bulls in safe surroundings in a bull pen, when most herds were peripatetic and roamed widely, is doubtful, but some measures would have to have been put in place.

Cows, oxen, and buffalos would have been treated with caution and respect because of their size and weight, which presented risks, such as being crushed or having a foot trodden on while the herds were being led. It must be remembered that some animals can be aggressive if they think their calves are threatened in some way. Young calves are also susceptible to attack from predators, such as tigers. A herder attempting to protect them can suffer any number of injuries, and some bites can be infectious, the usual organisms being Pasteurellosis (*Pasturella septica*), Haemophilus influenzae (*Haemophilus bronchisepictus*), and tetanus. Violent injuries from protecting a herd from human predators, such as rustlers, were also possible. The lives of peripatetic herders were hard and difficult; herds were large, and although it is unlikely that herders would be working alone, this would not have reduced the risks they faced.

Other Occupations

It is also possible to imagine other forms of injuries and illnesses that would have been incurred in other primitive workplaces. Continued exposure to loud noise will have caused some deafness. For those working in mines or quarries, such as those who excavated flint in the Rohri Hills and Ongar in Sind,[86] dust-borne particles, whether stone or ore, produces fibrotic changes in the lungs which are irreversible, leading in the long term to obstructive airways and chronic heart disease, not to mention the dangers of flint-knapping to eyes and skin. If the stone dust contains silicon, it can often lead to silicosis.

Even for food-production workers, other than zoonotic diseases contracted from their animals, the fungi growing in agricultural products can cause lung disease when inhaled. Grain processing in small and unventilated rooms could cause extrinsic allergic alveolitis, known today as 'Farmer's Lung', brought on by the inhalation of organic dust, produced by mouldy straw and grain. There would also have been hazardous atmospheres due to gases given off from rotting grain; consequently grain workers may have been exposed to unhealthy levels of airborne contaminants, including moulds.

[86] Biagi and Starnini 2008: 77-82.

Chapter Five

Public Health and Sanitation

The human skeletal remains from Harappa revealed evidence of nutritional deficiencies in adulthood and in childhood, episodes of disease or malnutrition. For example, tooth enamel hypoplasia was exhibited by 72% of observable permanent dentitions.[1] Strangely, enamel hypoplasia was not observed in the Middle to Late Harappan phase skeletons from Mohenjo-daro;[2] but they had other problems; there is evidence for sickle-cell disease and malaria, but we cannot altogether rule out evidence of anaemia resulting from acquired iron deficiencies due to chronic infection or excessive blood loss caused by gastrointestinal parasites;[3] nor can we rule out the prevalence of disease that does not leave lesions on human skeletal remains.

The pathogen load affecting the Indus Civilisation population in the Mature and Late Harappan phases also depended upon a variety of environmental factors. It had naturally increased with the event of sedentism in the Pre- and Early Harappan, and further increased with the event of greater population density, as these facilitate both the exchange of infectious agents between people in close contact with each other, particularly of density dependent diseases, exacerbated by the accumulation of human wastes and other refuse in and around the settlement. The human transmission of intestinal parasites, for example, is usually by the faecal-oral route and often is related to the actual size of the settlement and the extent of water supply and waste disposal.

In any society, sanitation and personal hygiene can moderate these effects, either consciously or sub-consciously. In Indus Civilisation cities, there is evidence that the inhabitants possessed certain standards of sanitation, the features of which were a basic clean water supply and an effective waste disposal. Their water supply and sewage disposal systems stand out as a major achievement of the Mature Harappan phase,[4] a greater achievement by far than those of the Near East, Egypt, or elsewhere in the Eastern Mediterranean.

The best example of public health and sanitation comes from Mohenjo-daro, which has produced evidence of a highly sophisticated system for water supply and disposing of sewage. Water not only supported industrial needs but was also for domestic use, as well as a system of private bathing platforms and the 'Great Bath', which would have been for public use. Fresh water was supplied by a network of wells.

Cities such as Harappa and Mohenjo-Daro were laid out according to a plan, with the drainage system coordinated alongside basic town planning. Drainage connections extended from most domestic buildings into open channels constructed of fired bricks in the centre of

[1] Lukacs 1992: 133-150.
[2] Kennedy 1984: 169-192.
[3] Beutler 2010: 518-527.
[4] *Water and Sewage*: *passim*; Webster 1962: 116-123; Ratnagar 2007: 82-9); Joshi 2008: 111-130; Kondo *et al.* 1997: 127-137. Summaries of the Indus Civilisation's drainage, sanitation and hydraulic engineering systems, can also be found in *Ancient Indus*: 122-127; and Khan 2014: 25-42.

the streets, which were either dug into the ground or constructed above ground. Although these houses were connected to the drainage channels, wastewater was not allowed to flow directly to the street sewers; the wastewater passed through tapered terracotta pipes into a small sump, where solids both settled and accumulated, while the liquids overflowed into the drainage channels in the street when the sump was approximately three quarters full. The drainage channels, usually covered by bricks and some stone slabs, could be removed during maintenance and cleaning. Also of interest was the inclusion of a cunnette, which was built to convey the smaller flows associated with day-to-day wastewater discharges, while the channel itself would have been used in the monsoon season, when much more water accumulated.

No drains, sewers, or wells, as part of settlement infrastructure, are reported from the Pre- or Early Harappan phases. Vertical water supply systems or wells appear to have been unknown in the emerging urban cultures of the earlier phases. It is therefore surprising to discover fully developed and structured water supply and effluent disposal systems, within what may have been roughly 300 years. The very presence of this infrastructure poses the question whether the inhabitants of Mohenjo-daro, for example, possessed any awareness of the dangers posed by faecal waste and the need for clean drinking water. It is likely that this is the case.

Water Supply

The population and workshops of Mohenjo-daro were supplied with fresh water through a system of wells which were vertically built, or sunken brick shafts up to 20 m deep. To allow for the smaller inner radius of the cylindrical well-shaft, they were built of specially designed, wedge-shaped fired bricks (Figure 10). The cylindrical well shafts are an exceptional feat of engineering as they prove that the circular form is by far best suited to withstanding the lateral pressure bearing on wells 20 m or deeper.[5]

The well shafts were likely to have been a local invention and were exclusive features of the Mature Harappan phase. If the average catchment radius was as low as 25 m per well over the whole of Mohenjo-daro, then it has been estimated that it must have been served by at least 700 wells, with an average frequency of one in every third dwelling,[6] without considering industrial needs, such as textile processes.

Many of the wells would have been deep and narrow and the drawing of water, container-by-container, would have been very labour intensive. Considering that many of the activities at Mohenjo-daro were diurnal, it is anticipated that most water entered the system at certain hours of the day, if it was for bathing. There would have been enormous demands on the system and one is left wondering the size of the labour force required to make the system work. It is likely that at Mohenjo-daro appropriately designed and weighted buckets at the end of long ropes was the likely system used for drawing water from the wells, and some well screenings show the characteristic wear-marks of ropes. A wheeled pulley at the well-head would likely have helped keep the bucket from swinging against the sides of the well, but we do not know when this was introduced into the region.[7]

[5] *Water and Sewage*: 122-124.
[6] *Water and Sewage*: 179-180; *Ancient Indus*: 122.
[7] Ratnagar 2007: 84-86, 89.

Figure 10. Large well at Mohenjo-daro, HR Area: detail of brick construction; Mature Harappan Phase (© J.M. Kenoyer/Harappa.com and courtesy of the Department of Archaeology and Museums, Government of Pakistan).

Having a vertical water supply system, it was a major achievement, in particular, to dig the wells and line them with the wedge-shaped bricks in a circular form. As far as we know, this form of vault was the only structure used to bridge larger openings in brick masonry, e.g. for covering drains and roofing doorways.[8]

[8] *Water and Sewage:* 179-180.

Such a densely populated city as Mohenjo-daro would not have survived long in a semi-arid climate without an independent water supply of its own, and thus ensuring the population's self-sufficiency, as the River Indus would have flowed past the city only irregularly. This does not, however, account for large volumes of water consumption indicated by the Great Bath, the bathing platforms that were located in nearly every house, and the density of its drainage network.

The Great Bath of Mohenjo-daro

The 'Great Bath' of Mohenjo-daro (Figure 11) is a structure with an area of *c.* 1700 m^2 (52 m north-south x 32.4 m east-west). It was discovered in the northern sector of the acropolis in 1925 and received its name from the brick-lined pool in the central courtyard. Referring to the other bathing facilities located nearby, a series of eight compartments built in two rows on either side of a central drain, Mackay wrote:

> "This bathing establishment is one of the most interesting buildings unearthed at Mohenjo-daro and affords much room for speculation. There can be no doubt that this group of rooms were used for ablutions... Most probably bathing was a religious duty, as with most Indians today and I am inclined to regard the bathrooms in Block 6 as provided for members of some kind of priesthood, whereas the general public performed their ablutions in the Great Bath."[9]

Figure 11. The 'Great Bath' at Mohenjo-daro, SD Area, looking north; Mature Harappan Phase (© J.M. Kenoyer/Harappa.com and courtesy of the Department of Archaeology and Museums, Government of Pakistan).

[9] *Further Excavations*: 20.

It is thought that the Great Bath was not included in the original plans for the city's acropolis but seems to have been a later addition. This can be determined from the way its covered drain cuts diagonally across the north-eastern corner of the lower and older section of the so-called granary adjoining it to the west. In addition, the method of construction of the basin itself, with an outer support wall and cross-wall reinforcements, indicates it was sunken into earlier foundations.[10] The outside wall, up to 2 m thick in places, was built utilising what we now call 'English Bond' and tapered upwards at an angle of 80°. The complex was separated from the neighbouring buildings on all sides by a street up to 5 m wide, making it the only known, single free-standing structure in Mohenjo-daro. In the Late Harappan phase, the perimeter was largely absorbed by secondary buildings.[11]

The centre of the complex was a sunken rectangular pool, measuring 12 m x 7 m and 2.4 m deep. Two opposite flights of ten steps each led down towards the basin floor from each end. The central courtyard with the basin was surrounded by a pillared gallery, through which it was entered from the south; the pillars themselves were set two pillar-widths apart. The two main entrances to the complex were in the southern facade and opened onto an anteroom, from where short irregular passageways led on to the pillared gallery, which in turn provided access to the central courtyard and further rooms in the east and north.

As described by Jansen, the access system of the complex was comprised of three concentric approach zones enclosing the central basin. The innermost zone was that immediately surrounding the basin in the central courtyard. The pillared gallery formed the intermediate zone, while the third was the public street surrounding the perimeter. A concentric layout of this kind, with a pool as its centrepiece, suggests that the approach zones were perhaps designed to serve yet another purpose, perhaps ritual processions of some sort. It must be admitted, however, that neither within the complex itself, nor in the pillared hall, which originally extended north of the central courtyard, nor anywhere else, did any material evidence turn up which could possibly indicate any cult significance for the Great Bath.[12]

The basin was supplied with water from a double-walled cylindrical well in one of the compartments bounding the pillared gallery on the east. This does not necessarily imply that the basin, with its capacity of 150 m^3 of water, was filled by hand, especially since they were such experienced hydraulic engineers; however, no traces of a filling mechanism has yet been detected. A drain outlet in the south-west corner of the basin allowed the used water to flow out into a larger brick drainpipe, *c.* 1.8 m high, which was large enough to walk through for purposes of cleaning and maintenance and was roofed by a corbelled vault. The extraordinary height of this drain tunnel may have been necessitated by the difference in level between the floor of the basin and the surface of the public street outside. After running northwards for *c.* 8 m the drain shifts to the north-west, cutting across the north-eastern corner of the lower section of the so-called granary. After another 40 m, it turns north again to bypass older buildings. The construction of the actual basin testifies to the high standard of Indus Civilisation engineering.

[10] *Water and Sewage*: 183.
[11] *Water and Sewage*: 183.
[12] *Water and Sewage*: 185.

The Great Bath and other larger buildings apparently fell out of use in the post-urban Late Harappan phase and their original functions discontinued, which is yet a further indication of the deterioration of urban living standards and the accompanying disintegration of the organisation of the city. On the other hand, the presence of Indus Civilisation artefacts in the uppermost layers implies continuity in the traditional crafts on a local level and hence weighs against the suggested sudden abandonment of the settlement.[13]

The Great Bath of Mohenjo-daro preserves for us the most outstanding structure known from the Indus Civilisation. Its special significance lies in its representing for the first time anywhere the idea of deliberate intra-mural extravagance in the use of water. However, the fresh water was still obtained from draw wells, i.e. by means of a vertical water supply system and not by means of aqueducts and underground pipes, thus a horizontal system. Yet this does not alter the fact that water was used on a lavish scale in Mohenjo-daro, as is obvious from the over 700 wells that ensured the bathing facilities in the private dwelling-houses were also kept amply supplied.

Domestic Bathing and Toilet Facilities

The level of structural engineering achievement and sheer frequency of the domestic bathing platforms in Mohenjo-daro, apart from the Great Bath, make them unique in the ancient world. A typical domestic bathing platform was installed inside the private house, either as a reserved area within a larger room or as a separate, custom-built 'bathroom' and consisted of a slightly raised platform floor, with an area of not more than 2 m^2, paved with especially sawn bricks of high quality and edged by a low brick rim to form a shallow basin. A special outlet in the outside wall allowed the effluent to flow into a soak pit or straight into the street drain, sloping to allow the used water to drain off, and built of several layers of fired bricks laid with the points in cross bond.

In many cases these private bathing platforms were bounded on one side by a short flight of only three or four steps, leading up to a small landing *c.* 80 cm high, from which the bather below could be showered down, presumably with buckets of water. Strangely, the large building in the DK-G Area of Mohenjo-daro had no such bathing areas.

The platform floor generally sloped towards a corner, where the effluent was directed either along a gutter, or through an outlet in the wall, whence it was discharged into the street drain or into a catchment vessel outside. Sometimes the floor sloped downwards on either side towards a central outlet in the outside wall. Drainage was simplified by the fact that the bathing platforms were usually situated on the street side of the houses.

Public latrines were often incorporated in the outside wall of the bathing platforms, sometimes fitted with its own vertical chute through which the sewage fell either directly into the street drain or into a cesspit (Figure 12). A wooden plank for sitting would have been placed across a pair of raised side supports. Latrines of the simpler type, however, still widely used in the region today, were also found, consisting merely of a hole in the ground above a cesspit.[14]

[13] *Water and Sewage*: 187.
[14] *Water and Sewage*: 189.

Figure 12. Latrine at Mohenjo-daro, HR Area; Mature Harappan Phase (© J.M. Kenoyer/Harappa.com and courtesy of the Department of Archaeology and Museums, Government of Pakistan).

Urban Drainage and Sewage

During different time periods and in different locations in human history, urban drainage has been considered singly or jointly as an efficient waste disposal medium; a cause of flooding; or a likely transmitter of disease. It is also clear that climate, topography, geology, engineering and construction capabilities, social values, religious beliefs, and other factors have influenced the local perspective on urban drainage. For as long as people have been building cities, these factors have guided and constrained the development of urban drainage.

Urban drainage is usually defined to include the disposal of two distinct types of water – wastewater and stormwater. Wastewater is water that after domestic, industrial, or sanitary

use must be collected and disposed of appropriately to prevent nuisances and polluted conditions from developing.[15] Stormwater is produced exclusively by rainfall. Both types must be considered during the construction of urban drainage systems; they can either be combined into a single conduit (combined sewers), or be kept separate if the rainwater is to be collected for other purposes. Urban drainage systems were constructed with great care, particularly if the objectives were to collect rainwater, prevent nuisance flooding, and convey wastes. This would have been achieved after much trial-and-error and many modifications.

The Indus Civilisation produced an advanced and efficient urban drainage systems in several of their more important major urban centres, particularly Mohenjo-daro, which they designed to provide the dual purpose of waste and stormwater conveyance and disposal. Mohenjo-daro featured a network of effluent drains built of waterproof fired-brick masonry along its streets. The drains mostly ran along past the houses on one side of the normally unpaved streets, some 50-60 cm below the surface; 'U'-shaped in cross-section, the sides and bottom of the drains were built of bricks set in clay mortar. Various coverings could be used for the open top (Figure 13), i.e. loose bricks, flat stones or wooden boards, that could be removed for cleaning as required. The width of the open top depended on the size of the bricks which ranged from 25 cm x 13 cm x 5.75 cm to 29.5 cm x 14.6 cm x 7.6 cm. Thus, a typical drain cross-section was

Figure 13. U-shaped cross section of the corbelled drain from Mohenjo-daro exiting the 'Great Bath'; Mature Harappan Phase (© J.M. Kenoyer/Harappa.com and courtesy of the Department of Archaeology and Museums, Government of Pakistan).

[15] Shereen Ratnagar suggests that the drains at Mohenjo-daro, for example, were used for domestic and possibly commercial sullage and not human sewage (Ratnagar 2016: 179-182), but the present author is not convinced by her argument.

probably 17-25 cm broad, by 15-50 cm high, and between two and eight brick courses deep. This gives a capacity range of between 260 cm^2 and 1200 cm^2.

The drains worked by gravity, sloping at a gradient of about 2 cm per metre and met at different levels depending on their depth. Curved structures were sited in such a way that frictional loss was cut to a minimum. Wherever a drain had to traverse a longer distance or several drains met, a cesspool was installed, this being the simplest method to avoid clogging by allowing solids to settle. The effluent flowed into the brick shaft at a high level, filled it and flowed out the other side at a slightly lower level. The suspended matter gradually formed a deposit which could be removed via steps leading down into the pit. These cesspools were also probably covered over with wooden planks and regularly cleaned.[16] It is interesting to speculate whether the drain and sewer system could cope with very heavy rainfall and would flood, thus causing additional public health problems.

Besides the closed sewage installations for disposing of domestic effluent, open soak pits were also in common use, especially where small lanes opened onto bigger streets, which would have had to be cleaned of settled solid deposits from time to time. In places where the street drain was too far away from the house, closed sewage catchment vessels were used instead. These were positioned under the vertical toilet chute outside the house and had to be tipped out regularly. In some cases, they were fixed permanently into the wall so that their contents had to be scooped out.

At Mohenjo-daro, there is evidence of public toilets being built into the outer walls of buildings. They were constructed from bricks with wooden seats and had vertical shoots through which the human waste fell into street drains or cesspits. These toilets were built *c.* 2600 BC and were in use for a considerably lengthy period. Some toilets were built within houses and were water cleaned, using flowing water, and were linked with drains covered with fired-clay bricks. The flowing water removed the human wastes.

It was not usual for houses to be connected to the sewage system by means of individual house drains, as the bathing and toilet facilities were generally situated on the street side of the houses where the effluent flowed straight down through a tapered terracotta pipe into the public drain below or else into some sort of catchment vessel. In many cases, these built-in chutes stopped short some distance above the relevant drain or vessel. For example, in House 49, HR-B Area of Mohenjo-daro, the effluent chute servicing two toilets ends short, which must have caused a dreadful smell. The presence of these wall chutes proves the original existence of at least one upper storey. Vertical terracotta drainpipes were also discovered. Consisting of a stack of conical pipe sections, each *c.* 60 cm long, which was built into the outside wall, such a drainpipe would have drained the roof or an upper floor.[17]

The offensive smells emitted by the sewage chutes, soak pits, cesspools, and sewers must have been a considerable public health nuisance, one which could only have been relieved somewhat by a constant high rate of flow and frequent cleaning, requiring a great deal of manpower to maintain effectively, and the maintenance of the drainage system must have

[16] Ratnagar 2016: 179-182.
[17] *Water and Sewage*: 189-190.

been a labour-intensive public service. This raises the question as to the type of institution which was responsible for this maintenance work and how it was financed. There are likely to have been dedicated water drawers and sewer cleaners at Mohenjo-daro, employing many hundreds of people. It is possible that wells were the responsibility of a family or group of families, but the sewer cleaning was certainly managed by the urban centre.

Of social interest is the fact that many pottery models and toys have been found in the sewers of Mohenjo-daro and it must be assumed that the childhood habit of playing with toys in the bath has persisted for millennia.

Other Sites

The evidence of public health infrastructure is usually presented from Mohenjo-daro, but there are examples from other urban centres. At the very end of the Mature Harappan phase at Nausharo in Baluchistan (Nausharo III), there is also evidence of a sewage system and a collective drain network located in a mudbrick residential block, each house had a fired-brick, water-resistant container on a platform, from which a drain or wooden planks, or fired-brick or a terracotta pipe with interlocking sections, led out onto the street. Such house drains emptied into mudbrick lined pits against the outer face of the house wall or into a terracotta jar, or a vertical series of perforated terracotta jars, and percolated into the ground.

Alternatively, waste-water was led out of the urban settlement by a 1.5-2 m wide fired- brick drain that ran between two residential blocks, receiving the discharge of water from houses to the east and to its west, and then went under the perimeter wall. The slope of this major street drain, oriented north-south, was *c.* 1%. It may also have discharged its waste into a basin at a distance from the settlement. What is not clear is the function of the mudbrick troughs along the street facades of the houses and their connection, if any, with this major drain. The mode of water supply to the settlement is currently unknown. There is not a similar system of wells as we see at Mohenjo-daro, although the settlement may have been much nearer a water source.[18]

In some other major urban centres, certain recurring features emerge. Though there is no parallel to the Great Bath at Mohenjo-Daro, at Lothal there is a row of 12 bathrooms on top of a large mudbrick platform at the highest end of the site, with large drains leading from them.[19] It is not certain whether they represent separate buildings or are part of one larger structure. There is also evidence of drainage and water supply at the site of Chanhu-daro.[20]

Discharge

The final question concerns discharge. One of the unknowns is where exactly the discharge from such a city as Mohenjo-daro occurred and whether there was any danger in contaminating rivers large and small and local agricultural land, the polluting effect of which creating the inherent dangers of many diseases, including cholera, typhoid, Leptospirosis,

[18] Ratnagar 2007: 84-86; Ratnagar 2014: 1-6.
[19] Rao 1979: 77.
[20] *Chanhu-daro*: 6-8, pl. XI.e. For wells, see *Chanhu-daro*: 4, 17, pl. XII.d.

and Weil's disease. In smaller urban and rural settlements without a mature public sanitary infrastructure, people may have gone outside the city walls to defecate, thus creating a health hazard of differing proportions. In smaller settlements, the disposal of human waste may have occurred intra-murally, thus creating further public health hazards.

Chapter Six

Healing and Medicine

The interpretation of archaeological finds from Indus Civilisation sites have not, so far, been able to provide us with any knowledge of healing and medicine in the period. The major urban settlements through their development of a public health and water supply infrastructure, however, do point to a keen level of alertness to public health and it is not unreasonable to assume that the inhabitants are likely to have also developed a structured system of healing and medicine.

At first, the curing of ailments was left to the body's natural restorative processes and to psychological aid, and a sound understanding of natural medication will have begun by the Pre-Harappan phase and presumably earlier, where by pure instinct, the population will have discovered remedies from plants, plant products, minerals, and animals and their products, which were ingested, inserted, or applied to the body. Many would be found to bring relief, or produce certain effects on their bodies, although any knowledge of their active substances and their pharmacological properties will have remained firmly outside their grasp. With the passing of time, by the 4th to 3rd millennia BC, medical practice in the Indus Civilisation will have developed out of observation, need, experience, and experimentation. The gradual building of an art of healing would have culminated in the Mature Harappan phase, with the increased sophistication of medical practices arising along the same exponential road as other aspects of their urban material culture.

The Egyptians in their Middle and Late Kingdoms enjoyed a unique environment in which medical practice could develop and be recorded, and it is not surprising that a society which could build the pyramids and other monuments should make contributions to the early development of medicine. The population of the Indus Civilisation are unlikely to have been any different; they too were monumental builders and enjoyed a complex society that was original and creative, and they must have developed medicine within a framework, consisting of compassion and care for the sick and injured, with the use of primitive therapeutics and surgery, as well as the use of magic and the invocation of the supernatural as an integral part of medical practice.

Whether, as in many other ancient societies, where the actual practice of medicine was determined by socio-economic inequalities, whereby an identifiable elite would have obtained better and preferential medical treatment, is unlikely, as our current knowledge of the Indus Civilisation's socio-economic system shows there is little evidence for social differentiation and exclusion, although at Harappa, based on skeletal evidence, it was probably not so in the Late Harappan phase.[1] It has been proposed that in the Middle Harappan phase, Indus society was a rare example of an egalitarian prehistoric state, which developed with no strong,

[1] *Peaceful Realm?*: *passim*.

centralised social control, or evidence of structural violence,[2] at least until the Late Harappan, and that this would have been reflected in their medical practice.

Healing and Religion[3]

In ancient societies, there was no clear-cut distinction between magic and religion and it is often impossible to categorise any one aspect of a belief system into one or the other, and the spiritual is usually indistinguishable from what we know as the rational. Included in this was an attitude to health and healing, which was often the continuation of magic by other means. From the very earliest times, humans will have decided that external and supernatural forces exercised a determining factor, favourable or unfavourable, on their lives. The Indus Civilisation would likely to have been no exception. They would have felt no reluctance to invoke their deities, as the cause of individual or systemic disease, or an epidemic, that threatened their community; there would have been no attempt at establishing a system of healing independent of the divine. Spirits or deities, believed by some to have been activated by human enemies, would be considered responsible for a disease or condition and, consequently, invocations would have been made to a deity to cure them of that disease or injury.

The Indus Civilisation would not have differentiated between therapies based upon physiological techniques, such as the administration of drugs, or the treatment of injured limbs, and those of a purely magical character. They would have applied both types of intervention in a single regimen of treatment. Suggestion and expectation of a cure, what modern clinicians now refer to as the 'placebo effect', would have had an important curative value, especially in pain relief, and its potency would certainly have been enhanced by the use of magic and incantations, or, as Arthur Shapiro suggests, it is the psychological or physiological effect of a medication or procedure given with therapeutic intents, which is independent of, or minimally related to, the pharmacological effect of the medication, which operates through a psychological mechanism.[4] Since some of the therapeutics known in the Indus Civilisation at the time are likely to have been pharmacologically ineffective, not only if misapplied, it is possible to assume that a belief in their potency would have been greatly enhanced by the use of magic.

What, at face value, appears to have been a magic process, very often has a rational basis, e.g. it may have been a magical process, with certain medicinal herbs having to be gathered at a certain time of day. There is, for instance, a diurnal variation in the concentration of many alkaloids in parts of plants, and where such alkaloids have therapeutic value. A good example is unrefined morphine from the opium poppy (*Papaver somniferum* L.), the efficacy of the preparation must be related to the time of day the plant is gathered, which is the first thing in the morning. The therapeutic efficacy of herbal remedies from a particular plant may be because of its resemblance to the organ or other part of the human body requiring treatment. As a parallel approach, a preparation made from an animal or an animal product might be

[2] Possehl 1990: 261-282. For a view on the class structure of the Mature Harappan, see Green 2021: 153-202.
[3] Some of the basic elements of this section of the chapter have appeared previously in Arnott 2016: 7-17, although some ideas have been revised here.
[4] Shapiro 1959: 299.

chosen because of the attributes of that particular animal, i.e. its hardiness or keen eyesight, the patient taking the preparation hoping to acquire the skills or the health of the animal.

Healing Cult

Many writers on religion and religious practices of the Indus Civilisation have debated the gender of deities and the nature of organised religion, but have ignored the probable existence of healing cult in any of the urban centres, both large and small.

Colin Renfrew has outlined the criteria for the identification of ancient cult practice.[5] It can be identified where there is archaeological evidence of: (a) attention focusing; (b) spatial aspects of the liminal zone, particularly with built structures; (c) the presence of the deity; and (d) participation and offering, particularly of human representation. This poses several important questions, the first being whether this paradigm can help us to understand more about healing in the Indus Civilisation. Do the so-called citadels in cities such as Harappa and Mohenjo-daro act as a liminal zone, wherein all cult activity is focused? Can we assume that human terracotta figurines, found wherever they are, have a cult importance, so that we might seek cult usage at the point of the greatest concentration of objects, and are they evidence for participation and offering? Is there anything that could be called a sanctuary? However, we can only do this through the process of inference, from the study of the material remains.

For any location to be classified as a sanctuary, it must be located at a place accessible to a settlement or group of settlements. If we can identify Indus healing sanctuaries, they would need to be locations where votive offerings were usually left as dedications to a deity or deities, then one can assume one of the principal reasons for visiting a specific sanctuary was a belief that the deity or deities dwelling there had healing powers. Not yet determined is the nature of the deity to whom offerings seeking healing and good health were made. The answer is complex but is likely to involve the existence of a particular healing god or goddess, who also ensured that its worshippers had enough to eat, but also cured their illnesses and helped them to see into the future. The idea of an overall or complete goddess of fertility, health and healing is appealing and is based mainly on an examination of the two principal types of figurines found in the Indus Civilisation – human and animal.

Most healing cults in antiquity are, by necessity, popular in both origin and use; they had a demonstrably community aspect to them and most of the votive dedications would have been personal and directed to achieving a relationship with the deity for healing and did not need the assistance of a priest if they existed within that society. However, the Indus Civilisation evidence does not point to exclusive healing centres, with their offerings to deities invoking health and healing, being practised to the exclusion of any other form. Disease and trauma do not discriminate and it is most unlikely that the health of communities varied significantly enough to precipitate a greater or lesser need for a healing cult. Of course, the intercession for healing, the preservation of health, or giving a thank offering for healing, was not always the main aim of the majority who attended a sanctuary and may well have been only of

[5] 5 Renfrew 1985: 18-26. However, many religious sites exist in the period which are both isolated open-air and built shrines within settlements, which are not represented by Renfrew's criteria, particularly when there is a clear bias, which the latter's model showed, towards the built as against the open-air shrine.

secondary importance at some sanctuaries, whose focus was on the livelihoods of those who left vast numbers of votives of domesticated animals, particularly cattle, seeking intercession in support of their economic wellbeing.

As to the location and nature of religious sanctuaries, where a healing cult may have been practiced, the archaeological remains of the Indus Civilisation show few structural remains that can be reasonably recognised as a sanctuary, or can be regarded as having a religious function. For example, several buildings at Mohenjo-daro have been tentatively called temples and some of the stone statuary associated with these buildings has been thought of as cult objects.[6] An example is House A from the HR Area in the lower town, where Wheeler described a ring of brickwork, 1.22 m in internal diameter, which has been suggested was a protective enclosure that surrounded a sacred tree.[7] The size of the structure would exclude large-scale rites at any one time. If this does depict tree cult, it will reflect not a collective ritual, but a more personal experience, such as perhaps invoking a deity for healing or to give a thank offering for a cure. Inez During Caspers has described the house in detail and confirms a public use.[8]

Three other similar round brick enclosures were found on the citadel in Area L, where they measure *c.* 1 m in diameter.[9] Others are reported from Chanhu-daro.[10] At Harappa there is evidence of acacia trees and related species standing inside a protective enclosing wall or railing, but the pipal tree is absent.[11] This is generally in conformity with the iconography on black-painted pottery from Harappa,[12] Mohenjo-daro,[13] and Chanhu-daro,[14] which shows acacia and pipal trees or saplings planted inside solidly painted enclosures or tubs, although it is absent on glyptic art.[15]

What is the significance of the enclosed acacia and pipal trees? The pipal tree can be found in other likely religious contexts. Three seals, possibly amulets, from Harappa show the pipal tree forming an arch over a standing figure,[16] and an intaglio from Mohenjo-daro shows a horned figure standing between the branches.[17] In other seals from both Harappa and Mohenjo-daro there are scenes of a similarly horned figure standing between two pipal branches or trees.[18] These representations suggest that the pipal tree possessed a horned 'spirit' or 'soul.'[19]

The small, circular brick enclosures referred to above, may well be earlier and suggest the practice of enclosing trees in low brick walls at Mohenjo-daro as objects of veneration. This may well have a long history, going back to the Early Harappan phase, and was not just confined

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[6] During Caspers 1990: 249.
[7] *Indus Civilisation*: 52-53.
[8] During Caspers 1990: 257-258.
[9] During Caspers: 251; *Mohenjo-daro*: 165, pls. XXX, XXX(b).
[10] *Chanhu-daro*: 3, 50, pls. XI(b), XVI(g)-(h).
[11] *Harappa*: 330-331, pl. XCIII, nos. 323, 325-328, pl. XCIV, nos. 329-332.
[12] *Harappa*: pp. 112, 128, 290, pl. XIX, no. 1.
[13] *Further Excavations*: 220, pl. LXX, no. 25.
[14] *Chandu-daro* : 93, pl. XXXI, nos. 2-3, pl. XXXII, no. 1a, pl. XXXVI, nos. 29, 37.
[15] During Caspers 1990: 253.
[16] *Harappa* : 331-332, pls. XCIII, nos. 307, 316-317.
[17] *Further Excavations*: 3370-338, pls. XCIV, no. 430, pl. XCIXa.
[18] *Mohenjo-daro*: 393-394, pl. CXVI, no. 1; *Further Excavations*: 351, pl. LXXXII, nos. 1a-c, 2a-c; *Harappa*: 331-332, pl. XCIII, no. 316.
[19] During Caspers 1990: 257-258.

to later phases.[20] The significance of the trees as important religious objects is emphasised by During Caspers[21] in that there is evidence that they could be moved. A scene from a seal from Mohenjo-daro[22] represents two naked men each carrying an uprooted tree, the roots emphatically rendered and being protected by a tree deity en route. They were probably for replanting; acts of sacrilege are not usually depicted on seals in the prehistoric and ancient world.

The identification of the pipal and other trees is not insignificant if one is to try to determine that this cult is linked to healing. As we have already seen, the pipal tree (*Ficus religiosa* L.) (see front cover) is depicted on some Mature Harappan iconography from major sites (Harappa, Mohenjo-daro, Chanhu-daro) as well as a tablet from Kalibangan.[23] During Caspers in her study of tree cults,[24] considers that some of the trees might well be acacias, but it is difficult to clearly identify the species of tree. The pipal tree has therefore not always been positively identified from the evidence. There is some suggestion that, as well as depicting acacia and pipal trees, both mature and saplings, there is also evidence of neem trees (*Melia Azadirachta* L. or *Azadirachta indica* L.), all planted inside solidly painted enclosures or tubs.[25] The two trees other than the pipal must therefore also be subjects of veneration, except that the neem and the pipal tree, especially, do seem to form a more central part to the cult. In the Indus Script, the pipal tree produces seven variants of depictions of its leaf and some of the minute steatite tablets from the Early Harappan levels at Harappa are in the shape of the pipal leaf.[26]

One of the special features of healing cult in the prehistoric world is that it is either directed towards the healing of the body or the mind, or both, or for the catharsis of those evil spirits that bring disease, pestilence, or bad fortune to a community. Those who practice the healing cult, be they individuals or even shamans, must have had a good knowledge of different plants and herbs, and their medicinal and magical properties, which also includes not only healing the sick, but perhaps preparing poisons to kill enemies.

The roles of the neem and pipal trees seem to have been central to Indus Civilisation medicine. As well as the iconography, also found in deposits at the site of Kunal were remains neem tree leaves, which have proven versatile healing properties, particularly with dermatological complaints (skin infections and wounds), fevers caused by malaria, internal parasites, and gastroenterological and liver disease.[27] Every part of the tree has a medicinal use – leaves, leaf extract, bark, gum, young shoots, blossom, fruit, seeds and seed oil, which are applied in combination with other medicines.

The pipal, or sacred fig tree, is a species of banyan fig native to India. It is known by various names other than pipal, such as peepal, peepul, pippala and pimpal, and, with the acacia, not as useful medicinally as the neem tree. It is a large, dry-season deciduous or semi-evergreen tree that grows up to 30 m tall, with a trunk diameter of up to 3 m. Also found in deposits at

[20] During Caspers: 258.
[21] During Caspers: 259.
[22] *Further Excavations*: 337, 341, 354-355, pl. XC, nos. a-b, 24a-b.
[23] Joshi and Parpola 1987: 313, no. K-76.
[24] During Caspers 1992: 102-127.
[25] During Caspers:116 and fig. 6.
[26] During Caspers: 117; *Harappa*, Vol. II, pls. LXXXIV(w), XCV, nos. 417-418.
[27] van Wyk and Wink 2004: 64, 104.

the site of Banawali, it is known for its astringent and laxative qualities, and as a treatment for dermatological conditions, such as warts and skin inflammation.[28] The acacia tree (*Acacia catechu* Willd.) provides gum for medical uses, and dried pulp extracted from the wood can be used as an anti-diarrhoeal, haemostyptic, and as a mild antibiotic.[29]

It is inconceivable that the population of the Indus Civilisation did not know of the therapeutic properties of these trees. It is also likely that because of their identification in their iconography they played a central part in the healing cult. The issues are not that it did, but was it a personal, private or domestic cult, or a public cult, and whether it entailed the intervention of a religious or magical individual, perhaps a shaman, to interpret the ritual, and, in effect, act as the promoter of a placebo effect as well? Shereen Ratnagar has discussed whether there were such individuals as Indus Civilisation shamans, and argues from the evidence that they may have existed.[30]

There would also have been forms of personal cures or protection against illness or injury through lapidary medicine, the treatment of symptoms by a belief in the curative effects of stones, talismans and amulets (as distinct from seals), which would have played an important primary role in faith-healing and auto-suggestion. Many would have believed that these objects had healing properties or fended-off those spirits thought to have been responsible for bringing disease to the family or community.

Magic power depended on the kinds of materials from which they were made, or on the subject engraved upon them, perhaps depictions of plants that invoked the potency, or assumed potency, of the real thing. It is therefore possible to putatively assume that, for the Indus Civilisation, healing would have been a part of popular religious activity, with its focus of ritual activity centred upon hypaethral cults. It would have been a 'cult of the living' and was inextricably linked to their political and economic life.

Indus Civilisation Healing Votives

The strongest evidence of a healing cult interpretation are the finds of complete human terracotta figurines – by far the major category of votives. Alexandra Ardeleanu-Jansen's study of the Mature Harappan terracotta figurines from Mohenjo-daro, places them into context in terms of chronology, iconography, likely use, and location.[31] While she does not directly address the issue of whether any of them might conceivably be healing votives, she does state that the corpus forms a highly diversified picture. An assertion that many of the corpulent female figurines may represent fertility is not altogether unreasonable and may be linked to some sort of fertility cult which venerated the reproductive powers of the female in the form of the great mother goddess, who has familiar parallels in other prehistoric societies. A few figurines are represented lying down on a bed or charpoy and this may indicate illness.

[28] van Wyk and Wink 2004: 410; *Rise of Civilisation*: 134, 148, 163, 211, 214-215.
[29] van Wyk and Wink: 28, 395.
[30] Ratnagar 2006: 111-115.
[31] *Retrospect*: 205-222.

As Ardeleanu-Jansen's study suggests, most of the Mohenjo-daro figurines were found smashed in secondary locations and none were found in a context that could be a cult location.[32] This had already been noticed by Marshall[33] and was probably the basis for his view that they served as votive offerings rather than cult images in a domestic shrine.[34] It is possible to imagine the catharsis of evil spirits, many of which would bring disease to an individual or a community, with a shaman performing a ritual whereby clay figurines, representative of that individual or community, had the evil spirits driven away by the breaking of the figurines, combined with other rituals lost to us and incantations.

For the existence of votives that involve healing or possibly a thank offering for healing, it is arguable that in most cases pathologies cannot physically be displayed, except those that would be indisputable, such as scoliosis brought about by tuberculosis of the spine or Pott's disease. Perhaps the indication of the specific disease was, in general, of secondary importance to the offer of the figurine. This would suggest that disease and injury were metaphorically transferred to terracotta figurines, which were then offered to the deity as the symbolic act of ridding the body of the illness. Of course, these figurines are only those preserved in the archaeological record. Others, now lost, will have included those made from very poor-quality clay, or organic material such as wood, which has not survived, or which were made to last for only one occasion.

As to the identification of deities that brought pestilence, disease, and healing, Asko Parpola, in his assumption that the language of the Indus Civilisation was an early form of Dravidian, notes that their principal native deity is *Murugan*, a youthful god of war and love, also associated with the much later Indo-Aryan deity *Skanda*, the north Indian war god. In Ayurvedic medicine, *Skanda* (or *Kartikeya*), often depicted with a goat-face, and believed by Parpola to be mirrored in some of the Indus terracotta figurines, is intimately connected with infants and human fertility. He also speculates that *Skanda-Kartikeya* as a disease demon (mentioned in the *Suśruta-Samhitā*, one of the basic works of Ayurvedic medicine) was feared for his fiery arrows which brought fever, and is a deity associated with blood.[35]

Medical Practice

There is currently no identifiable evidence, including iconography, of the existence of medical and healing practitioners, religious or practical, as we see in the Near East with its **āšipu** or incantation priest and exorcist, and the *asû*, the practical healer. What we do have is evidence of some of their work, demonstrated on human skeletal remains. Other than speculation surrounding the use of various remedies that have yet to be identified, because of the absence of soft tissue, amongst other things, it is not yet possible to identify any medical practice other than some surgery.

[32] *Retrospect*: 218.
[33] *Mohenjo-daro*: 340.
[34] *Mohenjo-daro*: 50.
[35] Parpola 1994: 225, 237-238.

Surgery

Surgery is an aspect of medicine directly concerned with the treatment of injuries or disorders of the human body by incision or manipulation, either by hand or by utilising instruments. The earliest surgical skills in the Indus region, including those which are instinctive and use teeth and fingernails, would of necessity have preceded what we know today as medicine and would have been used for the treatment of trauma, most specifically wounds to the long bones and head injuries. Their techniques would have come into existence because of the need to save life or limb and were most likely first performed as the result of combat, to arrest haemorrhage and to suture wounds.

As with most prehistoric societies, Indus Civilisation surgery would have been primarily related to the treatment of trauma, most specifically fractures to long bones and head injuries, the occasional removal of arrowheads, the application of bandages and compresses, methods of arresting bleeding, and the curing of wounds with unguents and medicines made with herbal extracts. There would also have been primitive surgical procedures for which we now have some evidence, although there is little to suggest that in the Indus region surgery was practised beyond the most elementary of operations. It would have been kept as a last resort because of pain, surgical shock, and infection. When performed, it would have consisted of relatively simple procedures, i.e. removing foreign bodies, the setting and manipulation of bones, as in the treatment of a dislocated mandible or a fractured clavicle, and would have probably made use of cotton bandages and swabs, plaster, splints and supports.

They presumably knew something of internal anatomy, and what understanding exists was probably by analogy with slaughtered animals, or from knowledge acquired from observing patients gored by a domesticated or non-domesticated animal, or who had been wounded in some way. One of the most difficult problems facing them would, of course, have been the removal of arrowhead barbs, where they would have enlarged the wound with a knife to extract the arrow, or may have pushed it through after removing the flight. In the Indus Civilisation there is evidence for the use of thin, flat arrowheads, with long narrow tangs.[36]

Cranial Trepanation[37]

The practice of cranial trepanation is the drilling or cutting through the cranial vault or craniotomy of a living or recently deceased individual. It was widely known and independently discovered as a process in many ancient societies in almost every part of the world, thus its discovery in South Asia comes as no surprise. In the Indus Civilisation, a great many of the injuries identified from whatever cause, combat, hunting, or occupational injury, were to the head and it is possible to identify a few examples of therapeutic cranial trepanation.[38] It was mostly performed on the parietal and frontal regions of the cranium, and occasionally on the occipital, for the removal of cranial bone, hoping to cause as little damage as possible to the underlying blood vessels, meninges, and brain. Initial incision of the periosteum produces a

[36] There are also copper examples rom Mohenjo-daro, see *Mohenjo-daro*: 499, pl. CXLIII.12 (DM61) (there are no flint or other metal types). From Chanhu-daro come copper and bronze examples, see *Chanhu-daro*: 9, 55-57, 183-184. There is a good example from Mound II, Section H (*Chanhu-daro*: no. 3309, pl. LXXIII.14); they are similar to the Mohenjo-daro type.

[37] For a short study of the cranial trepanning in the Indus Civilisation, see Arnott 2013: 23-34.

[38] Lisowski 1967: 651-672; Steinbock 1976: 29-35; Zivanovic 1982: 185-191. See also Arnott *et al.* 2003: *passim.*

lot of blood, but the haemorrhage can be minimised by turning back the scalp flaps created; a procedure no doubt adopted from almost the first therapeutic operations.[39] One can only imagine the pain suffered by the patient during the cutting through the periosteum; but the operation that follows is then relatively painless.[40] The patients were possibly anaesthetised with some compound, but in the case of head injuries they were probably already unconscious. It is significant, however, that throughout antiquity the proportion of survivors of this operation is relatively high, as evidenced by the osseous regeneration of bone around the operation site.[41]

While there are several ways the operation might have conducted, the evidence shows that an Indus Civilisation surgeon utilised the boring technique, although at Lothal there is evidence of sawing. Avoiding cranial sutures and major blood vessels, whoever performed the operation would remove the required area of bone by gradually drilling away first the lamina externa and diploë and then the lamina interna to expose finally the dura mater. The result was a very roughly circular and often quite small opening.[42] The drilling method probably allowed for a precise and controlled penetration of the inner table of bone and lessened the likelihood of brain injury. One aspect of the boring method would have been the time needed to perform the operation. Therapeutic trepanations performed as the result of trauma may have taken some time. With non-therapeutic trepanation, mostly the magico-ritual type, the time taken may have been only relevant to the nature of the ritual.

There is no evidence to suggest that there was any specific post-operative treatment, although this cannot be dismissed. Perhaps there was some attempt at closure of the skin wound, either by drawing together the skin flaps or by the application of a pad,[43] possibly of cotton. Roberts and Manchester have noted that in a number of trepanations from prehistoric Europe, osteitis and bone scarring surrounding a trepanation hole may be attributed to chemical irritants applied post-operatively,[44] but it is more likely to be due to infection of the wound.[45] It is possible to detect osseous regeneration on a number of trepanations, thus pointing to both recovery and the surgeon having skill in mastering the technical side of this operation, as well as possessing good hard and well-sharpened instruments. Over a lengthy period, increased technical efficiency must have contributed towards a higher recovery rate, but the chances of survival must have been hugely reduced by the surgeon carrying bacteria, such as *staphylococci*, from one patient to the next using unsterilised instruments.

The operation would have been performed in the hope of curing intracranial disease or extradural haematoma, more common in the parietal region of the cranium, persistent migraine, or paralysis. Additional conditions might have been vascular accidents, inflammation of the mastoids, severe neuralgia, or possibly even coma. But it is more likely that it was a surgical clearing-out for the removal of splinters of bone, or even an embedded weapon or tool, from a head injury, brought about by combat, hunting, or agricultural activity, or to alleviate pressure resulting from concussion. It is interesting to speculate whether they knew of the association of head injuries and intracranial pressure. We cannot rule out, however, the likely magical or

[39] *Disease*[3]: 124.
[40] *Disease*[3]: 124.
[41] *Disease*[3]: 124.
[42] Lisowski 1967: 662-663.
[43] *Disease*[3]: 124-128.
[44] *Disease*[3]: 124-128.
[45] Stewart 1957: 461-491.

symbolic practice of the operation on the living for the curing of perceived 'mental illness', such as epilepsy, schizophrenia, convulsions, or even for the catharsis of 'evil spirits', although this procedure could often be unknowingly therapeutic, as a variety of conditions considered to be caused by these 'evil spirits' could be treated by trepanation.

We know very little about the specific origins of trepanation – its beginnings are not to be found in rational medical practice. As in other ancient societies, trepanation would have made its first appearance in the region as a ritual act, and experience would have taught that humans could survive the operation and a crude technique for doing it was learned, which would eventually have led to its refinement for medical use. Until quite recently, the evidence for trepanation in the Indus Civilisation has come from only four sites, but this does not render trepanation unique to these sites, as these cemeteries are amongst the only ones so far discovered and fully studied. Because of the examples of trepanation from prehistoric Europe,[46] Stuart Piggott first suggested that central and northern Europe may have witnessed its origins for that region.[47] However, we know of the use of early trepanation in the Aegean[48] and the Near East; in the latter we now have evidence for the procedure as early as at the site of Zawi Chemi Shanidar in Iraq, dated to the Proto-Neolithic,[49] thus pointing to independent invention in these societies, as in India.

In the Indus Civilisation, there are five known examples from the cemeteries at Lothal, Kalibangan, Cemeteries R-37, and H found at Harappa; there is also an example from Neolithic Burzahom in Kashmir, contemporary with the Mature Harappan phase (Table 12).

Table 12. Cranial trepanation (after Arnott 2013: 23-34).

CRANIAL TREPANATIONS				
Site	**Date**	**Sex and Age**	**Type**	**Inventory/Skeleton Number**
Lothal	Late Harappan	Child, aged 9-10 years	Sawing (?)	SK. 15
Kalibangan	Mature Harappan (Kalibangan II)	Child	Boring	KLB 8/69 (Burial 9)
Harappa (Cemetery R-37)	Mature Harappan (Harappa 3)	Middle-aged Adult male	Boring	H802/B
Harappa (Cemetery H)	Late Harappan (Lower Stratum II (H2)	Adult male	Boring	H796/B
Burzahom	Burzahom Neolithic II (2300-2000 BC)	Young female adult, aged 25-35 years	Boring	SKL7, BZH-3

[46] Lisowski 1967: 652-654.
[47] Piggott 1940: 116.
[48] Arnott 1997: 249-278.
[49] For a review of trepanations in the Ancient Near East, see Mogliazza 2009: 187-192.

Lothal

The study by S.K. Basu of the human skeletal remains from Lothal[50] shows evidence of the skull of a child (SK. 15), aged 9-10 years old, found in Grave 12, a Grave Pit (dated to Phase IV, Mature to Late Harappan), having had a cranial trepanation performed, uniquely for the region, using the sawing method. The right parietal shows a deficiency anteriorly at the anterior and lower quadrant almost midway between the parietal eminence and the squamose-parietal suture. The bevelling of the margins might have been produced by some instrument before the child was buried. There is no osseous regeneration, so it may be that the child did not survive the trepanation or that it was even post-mortem. No other skeletal lesions point to the need for the operation and there are some post-cranial bones with no pathology evidenced.[51] Consequently to this discovery, S. R. Rao has reported the discovery from Lothal of a bronze saw with a curved blade, with three teeth remaining, which could have been used for this or another similar operation.[52] Another possible candidate as the instrument used in this operation was one of the saw-edged or pointed chert blades found at the site.[53]

Kalibangan

On the cranium of a child from Burial 9 at Kalibangan (Kalibangan II period, Mature Harappan) (KLB 8/69) excavated in 1962-1963, the right side of the child's cranium shows three small trepanation holes on the squamous temporal, above the right acoustic meatus as the result of the use of the boring method. There is also a black streak joining the upper two holes and running up to the right opistocranion point might have been caused by some hot pointed instrument. The burning mark and holes combined are suggestive of a very primitive surgical operation, performed on the skull of the child to give him or her some relief from the severe pain that is caused by the swelling and by the desensitisation of the adjacent nerve ends by quarterisation. This probably also accounts for the presence of more than usual wormian bones on the same cranium. As there is evidence of healing and osseous regeneration around the trepanation site, it is likely that the child survived. The huge globular size of the child's skull suggests a case of hydrocephaly, caused due to excessive accumulation of water in brain cells, which produced swelling and pain. The trepanation and quarterisation were therefore performed to relieve the pain caused by this swelling of the cranium.[54]

Harappa

Amiya Chowdhury has produced evidence of trepanation in Harappa on a cranium of a middle-aged adult male, H.802/B, from Cemetery R-37, dated to the Mature Harappan phase;[55] the individual suffered two depression fractures on the right parietal (Figure 14). A fracture superior to and running parallel with the temporal line caused plastic deformation and upheaval of the bone from the coronal suture to the parietal eminence. A second fracture runs perpendicular to the first: from the sagittal to the squamous suture. This fracture

[50] Rao 1973: 149-151.
[51] Rao 1973: 149-151; Rao 1979: 145-146, 167; Sarkar 1972: 122.
[52] Rao 1973: 150; Rao 1985: 533. A similar saw has been found in Room 9, Block 12, Section C of the DK Area at Mohenjo-daro, see *Mohenjo-daro*, Vol. II: 500-501, pls. CXXXVII.7, CXXXVIII.8 (C100-1).
[53] Rao 1985: 558-559, fig. 122.7.
[54] Sharma 1969: 111; Lal 1997: 218-219; Sharma 1999: 28-33, 92-93.
[55] Roy Chowdhury 1972: 203-206.

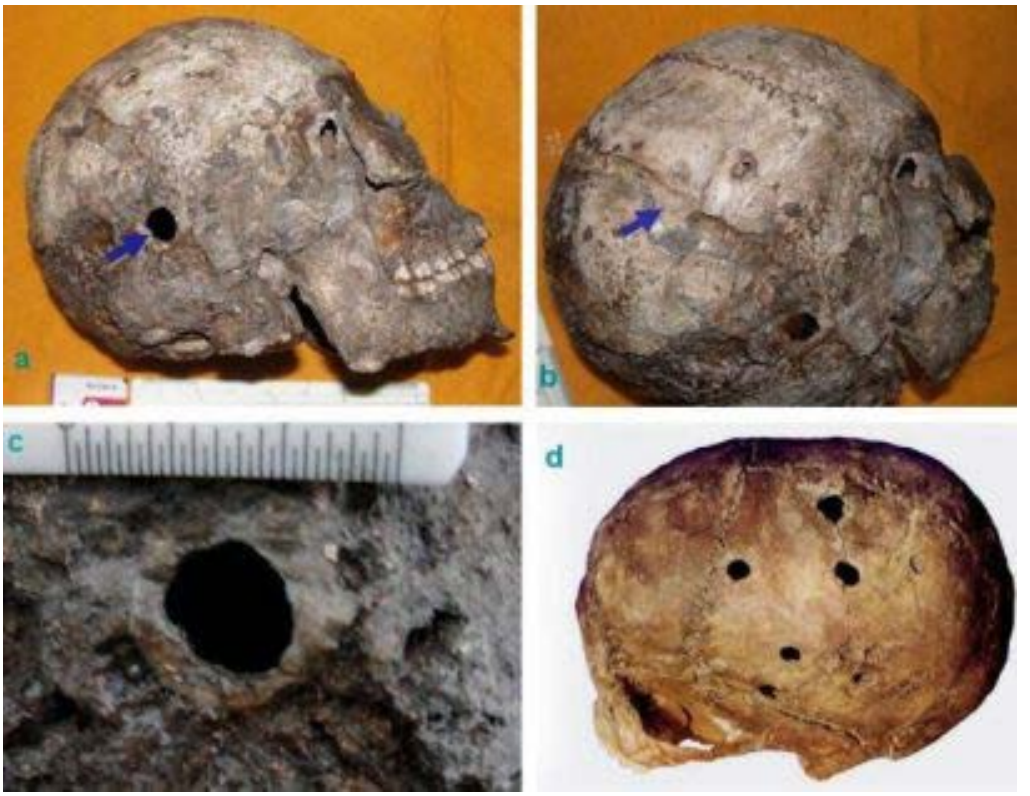

Figure 14. Trepanned cranium of an adult male from Harappa (Cemetery R-37) (H802/B): (a) the left lateral view showing the trepanned hole; (b) the postero-lateral view showing the horizontal linear traumatic fracture on the occipital bone; and (c) an enlarged view of the trepanned site showing the rim of callous formed due to healing (after *Peaceful Realm?*: 140).

left a depression, *c.* 50 mm in length and 20 m in breadth. There is no evidence of healing or remodelling around either of these lesions. A round hole (5 mm in diameter) has been described previously as a trepanation.[56]

This trepanation seems to have been performed to the temporo-parietal bones using a small circular gouge with an alabaster handle, suitable for the boring method, that was discovered in the same strata as the grave. Strangely, and what raises some doubt, is that the original excavation report that discusses the crania in such detail makes no mention of these skeletal markers. However, the volume in question contains no discussion of pathology and it may not have been a consideration of the authors,[57] their only real interest being cranial anthropology.

Sankhyan and Robbins Schug have re-examined the Harappa crania from the Palaeoanthropology Repository of the Anthropological Survey of India in Kolkata.[58] They have published the trepanned cranium of an adult male from Cemetery H (H796/B), dated to the

[56] Robbins Schug *et al.* 2012: 140.
[57] Gupta *et al.* 1962: 19, 21, 30-31, 184, fig. 18, pls. VII-VIII.
[58] Sankhyan and Robbins Schug 2011: 1621-1622.

Later Harappan. The bored trepanned hole is just on the right superior temporal line at the terminus of the traumatic line. A clear bevelling of 3 mm width at the internal border of the hole is evidence of osseous regeneration or healing, indicating that the victim survived for a period after the operation.

A further study by Robbins Schug *et al.* suggests that the raised margin around this hole has been interpreted as indicating sclerosis; however, they are apparently coated with preservative and not entirely visible and the researchers have concluded that the trepanation can only be fully confirmed by imaging the rim and the internal compact bone using computed tomography. Until that imaging is complete, the diagnosis of trepanation remains speculative.[59]

Burzahom

The best recorded trepanation comes from the site of Burzahom, 10 km north-east of Srinagar in the Kashmir Valley, in modern India.[60] The site, excavated from 1961 to 1968, has yielded ten human skeletons from different local Neolithic and Neolithic-megalithic cultures. The Neolithic Phase II, suggested by radiocarbon dating to 4300-4000 BP (*c.* 2300-2000 BC),[61] contemporary with the Mature Harappan phase further south, has produced seven inhumed human skeletons,[62] including one with a trepanned cranium (SKL7, BZH-3). The remaining three skeletons belong to the Neolithic Phase I, with an earliest possible date of 4375±120 BP (*c.* 2375 BC).

The graves in which the human skeletal remains were found were pit burials. The burial of the trepanned adult female, aged *c.* 25-35 years, was accompanied by animal bones, antler or horn pieces, and a circular soapstone disc associated with it. The skeleton was in its primary articulation and in a crouching position, oriented north-east to south-west, and was found at a depth of 2.24 m from the surface level. The trepanned side of the cranium was lying upwards, towards the surface.

The trepanation on the cranium was first observed by Bridget and Raymond Allchin,[63] but later studied by Roy Chowdhury *et al.*[64] The two studies come to different conclusions; Basu and Pal questioning Allchin and Allchin, who originally suggested the trepanation was clearly undertaken for medical purposes. The later study by Sankhyan and Weber shows unambiguous evidence of multiple trepanations;[65] they detected 11 attempts at trepanation on this woman, probably trepanation holes 2, 3 and 5 were made first, followed by numbers 1, 4 and 6. This is quite speculative, but may be understood from a close study of the cranium. Barring a minor depression on the top of the right parietal, all the attempts are found on the left parietal. Depending on the nature and depth of the depressions and holes, they distinguished at least four unsuccessful attempts and six completed perforations, which represent the final stage of trepanation. All holes are bored nearly circular or oval in outline, ranging in maximum diameters from 5-14 mm.

[59] *Peaceful Realm?*: 140.
[60] Sankhyan and Weber 2000: 375-380.
[61] Agrawal and Kusumgar 1965: 42-43; Agrawal *et al.* 1966: 5.
[62] Basu and Pal Human 1980: 15-19.
[63] Allchin and Allchin 1968: 159.
[64] Basu and Pal Human 1980: 15-19; Roy Chowdray 1972: 203-206.
[65] Sankhyan and Weber 2000: 375-380.

The first three are neatly and carefully performed and are almost of the same size and outline. They were most likely made by the same instrument and surgeon; there are no fracture lines emanating from them. The others, however, are bigger and were most likely made with a different instrument. It is probable that the later holes were created at the terminal stage, with less care and more force, even blows; the vault was fractured as is seen from the fracture line connecting the three. No instruments that could have been used were found at Burzahom. However, flint instruments, but no bronze instruments typical of the Indus Civilisation to the south have been recovered. It is probable that drills of various diameters were used on the skull; cutting or scraping is less likely.

Sankhyan and Weber thought that at least some of the trepanations on this skull might have been performed by a peripatetic surgeon with his own bronze instruments. It seems that the whole series of operations was performed in quick successive stages of short duration. No clear evidence of osseous regeneration is visible inside or outside the punctured holes. Evidence that this was a surgical operation may be taken if the left hypertropy of the skull is interpreted as an anomaly or cranial disease. As it is, one can only speculate that this woman with a slightly abnormal skull may have been possibly epileptic or otherwise 'different' and such people were regarded with awe and fear in most early societies. What it is, we simply do not know. This is unfortunate as it would have allowed some general conclusions to be reached on the reasons for this and other trepanations.

Basu and Pal[66] believe that this multiple trepanation was undertaken post mortem with the purpose of obtaining roundels for cranial amulets, to be used for ritual or other votive offerings or magico-religious practices, and argue that the left portion of the trepanned side of the skull was facing upwards and that the skeleton was treated with red ochre. There is no evidence for this. With parietal osteoporosis, a possible diagnosis of some of the cranial holes, the normal bone shelves into a thinned area, which is quite fragile and can leave an opening with a bevelled circumference and an appearance of healing, imitating a trepanation.[67]

The skeleton of the trepanned skull was in primary articulation, i.e. undisturbed by any agency after burial. Why were six holes cut and five more left as depressions? Not much care is needed for cutting roundels from the skull of a dead person, nor have other trepanned crania been found at Burzahom. If roundels were desired, one would find deep cuts around the circumference of incomplete holes. In addition, there is no evidence of prehistoric or contemporary tribal or non-tribal people of South Asia in general using cranial roundels as amulets or for other purposes.[68]

This carefully performed trepanation, with the likelihood of several attempts at a successful operation on a possibly anomalous skull, does argue for a clear case of surgery performed for predominantly medical reasons on a living person – who did not survive the procedure. We must not forget that in most primitive societies diseases are regard as an invasion of spirits which are usually, but not invariably, thought to be evil. Also, medical and surgical procedures in such societies are so closely intertwined with belief, ritual and magic that they cannot neatly be separated. Cases of mental illness, epilepsy, and suchlike, are also widely regarded as

[66] Basu and Pal 1980: 15-19.
[67] Sankhyan and Schug 2011: 1621-1622.
[68] Sankhyan and Weber 2000: 375-380.

messengers of their deities, with the afflicted often given a very special, even sacred, position in society. Trepanation in the case of the Burzahom cranium and elsewhere could merely represent the surgical part of a much more elaborate medico-ritual ceremonial procedure of which only the trepanned skull survives.

Trepanation Techniques

There is the question whether there is any consistency in trepanation technique used in trepanations found in the Indus Civilisation or its contemporary neighbours? The trepanation from Lothal seems to have been undertaken by the sawing method, but the other three cases identified as trepanations were undertaken by the boring method, using a special instrument of some kind, which seems to have been the technique of choice, not unlike other ancient societies around the world, although no such instrument has been found. Where there seems to be no consistency are the reasons why the trepanation was undertaken. All three criteria might apply but is seems that most were performed for therapeutic purposes. Other than the small saw found at Lothal, stone or bronze tools that might have been used for trepanation have as yet not been found.

Brain or Cranial Surgery?

As stated in the Introduction, we are reminded that cranial trepanation is surgery to the cranium or skull; it is not brain surgery as some scholars have wrongly speculated. It would be millennia before such surgery would be attempted. In the recent paper which examines the cranial trepanation on a male cranium from Lower Stratum II (H2) of the Late Harappan Cemetery H at Harappa, Sankhyan and Robbins Schug start their discussion by reporting the first unequivocal case of ancient brain surgical practice, known as trepanation.[69] This follows on from an earlier attempt at suggesting the existence of brain surgery in the Indus Civilisation by Jagat Joshi in his review of the archaeology of the civilisation.[70] It is extremely naïve of some scholars to make this suggestion, as cranial trepanation is, in fact, cranial not brain surgery, a huge difference. The latter was not attempted by any ancient society and is not even hinted at in any later Ayurvedic medical texts. Not only is the idea that at the end of the 3rd millennium BC surgeons could perform brain surgery implausible, but there is absolutely no evidence to suggest why the Indus Civilisation trepanation was performed, most likely for the treatment of trauma, and thus to make this suggestion is quite misleading.

Orthopaedics

In ancient societies, as anatomical knowledge invariably and gradually increased, an understanding of infection, but not the nature of, for example, osteomyelitis and gangrene, may have developed. It must be expected therefore, that this would have been followed by the introduction of the surgical amputation of limbs, the deliberate removal of part or all of a limb carried out as a surgical procedure for the treatment of disease, infection, injury, or even as a punishment. This is quite apart from traumatic amputation, which is caused by injury on the battlefield, or in the home or workplace.[71] There is in the Indus Civilisation no skeletal

[69] Sankhyan and Robbins Schug 2011: 1621-1622.
[70] Joshi 2000: 20.
[71] Evidence of amputation in the archaeological record is generally rare, but it may be a problem of identification. A

evidence for non-traumatic amputation as they possessed insufficient clinical knowledge to understand the nature of gangrene and other serious infections, or, alternatively, they may have shied away from major limb amputation primarily because of the inability to stem fatal blood loss or even for reasons of religious taboo. The ancient Egyptians, for example, knew only too well the effects of gangrene,[72] but even there, limb amputation did not usually feature as a surgical procedure for religious reasons.

In the 3rd millennium BC, the breaking of a bone was a serious matter. The long bones, such as the femur, are surrounded by powerful muscles that will contract strongly around the site of a fracture and are the most common causes of this misalignment. A good healing of a major fracture is perhaps even less likely in the case of compound fractures. When added to the long period of immobilisation, dependence upon others, and the later disablement due to a shortened leg, it may be possible to have some insight into some of the sufferings in antiquity from traumatic fractures.[73] The process of repairing a fracture is often complicated by inflammatory reactions due to infection or osteomyelitis, giving rise to fever and a delay in healing; the individual may have been forced into an unwise early mobilisation, often resulting in deformity of the bones and some loss of function.[74]

Roberts and Manchester have explored the social and economic dimensions of trauma in so much as it affects the family or community group. The satisfactory healing of fractures in adults is a long process which takes many weeks of immobilisation, during which time complete rest of the injured part is essential. This may not have been too difficult in the case of upper limb fractures, where the individual may have been able to perform some tasks, but it would have been much more serious in the case of a fracture to a lower limb.

If the individual survived the trauma, he or she would have been entirely dependent upon the community for as long as three months if a badly fractured femur were involved.[75] For urban dwellers perhaps this would not have necessarily posed a problem, but for the small rural agricultural communities, or family groups, this may have meant a severe blow to their lives, if the individual with the fracture played a pivotal role in their economic life. Of course, the immediate attention afforded to those with properly healed fractures, and the long-term patience necessary for proper healing, helps illustrate the caring structure of past societies, including the Indus Civilisation. Of equal, or perhaps greater concern would have been dislocation, especially to the humerus/shoulder joint. It is often not possible to manipulate the joint back into place and permanent dysfunction would often thus occur. However, the treatment of some dislocations must have played a part in the orthopaedics of the period.

As to the treatment of fractures, many of which were brought about by combat, occupational injury, or by being gored by a bull or other animal, bonesetters with a knowledge of simple bone setting would have been in great demand; the simple and primitive expedient of holding

healed amputated limb might well be mistaken for post-mortem breakage; in both cases there would be no evidence of healing and the patient would have died soon afterwards, perhaps from a massive haemorrhage. It is also possible that an amputation may be confused with an un-united fracture, where no attempt has been made at healing, and where, for example, the distal fragment is missing (*Disease*[3]: 90).

[72] Breasted 1930: 264-265 (case 15), 385 (case 41).

[73] *Disease*[3]: 95.

[74] Manchester 1987: 168.

[75] *Disease*[3]: 94-95.

together the parts of a broken staff by bounding them to a sound staff would naturally occur to any people of intelligence and its application to a broken bone would not be very hard to imagine.[76] It has been concluded that the proof of the existence of surgical orthopaedic practice is that fractures just do not spontaneously heal in the manner evidenced by the skeletal remains. This conclusion agrees with a recent study of fractures in wild animals that contradicts the commonly held view that their fractures heal without reduction.[77] Techniques such as fracture reduction may have developed empirically, perhaps even from the experience of herdsmen and shepherds treating animal fractures.

Other Surgery

Unfortunately, only surgery involving bone can be identified, thus simple operations such as the lancing of boils and the removal of bladder stones, common in early societies, are lost to us, although we must assume that treatment of superficial trauma was very conservative and major operations unlikely. Unlike in some contemporary societies,[78] there also appears to be no iconographic evidence for male circumcision or any other form of medical treatment.

Ghislane Lawrence has stressed that while the history of surgery has generally been perceived as the history of the attempts to cure morbid anatomical conditions, we really know nothing about a society's surgical techniques. Such as these were, they were likely to have derived from hunting and butchery, with much of the necessary anatomical knowledge for surgery and medicine probably growing from early man's increased dependence on meat.[79] She goes on to question whether surgeons cut like barbers, cooks, or craftsmen, and asks if flaying or jointing could relate to any clinical procedure.

Dentistry

While dental surgery appears very early in the ancient skeletal record, starting in the Pre-Harappan phase, we have little real evidence from the later Mature Harappan for it, i.e. the deliberate intervention in the treatment of dental disease. This is surprising in that some other simple surgical procedures, which presume a rudimentary knowledge of human anatomy, were being successfully performed by the Harappans. Drilling a carious tooth, wiring loose teeth, or fashioning a simple prosthetic device to bridge a gap, are simple procedures that could easily have been undertaken by a jeweller or other form of craftsperson skilled in these matters. It is accepted that dental extractions are not that easy to successfully perform and require skills or complex instruments,[80] but one of the varieties of bronze tools in use in an Indus Civilisation craft workshop could have been used for this purpose. Dentistry, where it existed, seems inevitably to have been more widely practised in the urban rather than in rural areas, as suggested by the evidence of the incidences of abscesses despite the higher number

[76] Clark 1937: 47.
[77] Christopher Bulstrode 1990: 19-23.
[78] Nunn 1996: 169-170.
[79] Lawrence 1992: 307.
[80] While some believe that it was a simple operation, the apparent simplicity is due to a series of carefully designed pressures in various directions depending upon the shape of the root of the tooth, and to undertake the extraction safely without damage to the surrounding tissues does indeed require sophisticated instruments, e.g. special forceps. Forceps used for removing bone splinters and arrow heads are completely unsuitable, since they would touch the tooth only in two places. However, such dental forceps are yet to be identified.

of dental caries. Practical dentistry may have been practised as a profession in the large Indus Civilisation urban centres.

The oldest and first evidence of dentistry in the Neolithic, showing the drilling of human teeth *in vivo*, was found in 11 drilled molar crowns from nine adults discovered during a post-excavation study (during 2000-2003) of the human skeletal remains from cemetery MR3 of the Early Neolithic levels at Mehrgarh (Mehrgarh I), dating to *c.* 7000 BC.[81] The cemetery contained more than 300 graves and was in use over a period of 1500 years. The site lies along the principal route connecting Afghanistan to the Indus region. After intermittent occupations by hunter-gatherers, its subsistence economy shifted to the cultivation of barley and wheat, cotton domestication, and cattle breeding; the relevant archaeology records an increasingly rich cultural life, with some technological sophistication based on diverse raw materials.

Small perfectly formed holes from the molar crowns of nine adults (four females, two males, and three individuals of unknown gender) were detected, and it was found that the holes were too perfectly round to have been caused by bacteria. But the study did observe a series of concentric grooves left by what they believe was a drill with a very small stone bit. Drilled teeth were evident in both jaws (four in the maxilla; seven in the mandible) and exclusively in the first (four specimens) or second (seven specimens) permanent molars. Except for one located on the distal-buccal cervix of a lower first molar, the holes were bored into enamel or secondary dentine on the occlusal surfaces. The holes are 1.3-3.2 mm in diameter and angled slightly to the occlusal plane, with a depth of between 0.5-3.5 mm.

Light microscopy, scanning electron microscopy, and microtomography revealed cavity shapes that were conical, cylindrical, or trapezoidal. They also showed concentric ridges preserved on some walls that had been left by the drilling tool. The teeth of at least one individual reveal that the procedure involved not just removal of the tooth structure by the drill, but also subsequent micro-tool carving of the cavity wall by either the operator or the patient.

In all cases, marginal smoothing confirms that drilling was performed on a living person who continued to chew on the tooth surfaces after they had been drilled. Complete dentition for the 11 specimens is not preserved, so the incidence per jaw cannot be determined. However, one individual had three drilled teeth and another had a tooth that had been drilled twice. Four teeth show signs of decay associated with the hole, indicating that the intervention in some cases could have been therapeutic or palliative. But as caries can exist in individuals in the absence of drilling, and drilling may be done in individuals without caries, the motive for the early Neolithic dental procedure described here is unclear. Aesthetic functions can be ruled out because of the deep placement in the jaw. The perforations exposed a sensitive tooth structure, so some type of filling may have been placed in the cavity; however, no evidence survives to confirm this.

Whatever the purpose, tooth drilling on individuals buried at MR3 continued for about 1500 years, indicating that dental manipulation was a persistent custom. After *c.* 5500 BC, the practice must have ceased, as there is no evidence of tooth drilling from the subsequent MR2 Chalcolithic (Mehrgarh II) cemetery, despite the continuation of poor dental health.

[81] Coppa *et al.* 2006: 755-756.

At Neolithic Mehrgarh, flint drill heads capable of undertaking this form of dentistry occur in the lithic assemblages associated with beads of bone, steatite, shell, calcite, turquoise, lapis lazuli, and carnelian. Using models of these drill tips, a method was reconstructed for drilling based on the ethnographic literature and it was found that a bow-drill tipped with a flint head required less than one minute to produce similar holes in human enamel. Presumably, the know-how originally developed by skilled artisans for bead production was successfully transferred to drilling of teeth in a form of proto dentistry.[82]

Detailed investigation of worn teeth can not only reveal a record of past activity patterns, including craft or occupational activities, but a study of the dental samples from Neolithic and Chalcolithic levels at Mehrgarh and Pre- and Mature phase Harappa has yielded evidence of activity-induced dental abrasion such as interproximal tooth grooving of maxillary incisors in association with rounded wear of lower incisors, probably due to habitual idiopathic tooth probing, perhaps to alleviate pain.[83]

Medical and Surgical Instruments and Equipment

Few instruments from the Indus Civilisation so far been discovered or identified from previous finds can be even remotely suggested as being specifically surgical. While many of the instruments used by healers for surgery will have been of copper or bronze, they do not always make the most efficient tools for cutting flesh or even bone, as they blunt quite easily. Hard stone tools, especially knives or scalpels, made from the stone ubiquitous to the Indus region, chert, would have been more in use as surgical instruments, as is also attested in ancient Mesopotamia, where stone tools made from obsidian (*surru*) was also used. Some of the so-called 'cosmetic objects' found at Harappa or Mohenjo-daro, and now on display in the National Museum in New Delhi, such as probes made from ivory, bone or bronze, and the much-illustrated joined spatula or toiletry gadget from later levels (Mound AB) at Harappa, comprising what was thought to be an ear scoop, piercer, and tweezers (Figure 15),[84] could conceivably have had a surgical use, and possibly Near Eastern origin. The small bronze saw found at Lothal may have been used for trepanning.

One must be very cautious when applying modern terminology to ancient medicine. Those medical historians who write about the surgical instruments often see their primary task as simply identifying the earliest references to new surgical instruments in the literature, or their occurrence in the archaeological record. Only one or two have considered that these objects are the outcome of lengthy processes of invention and innovation, and most assume that surgical instruments are directly revealing of the history of surgery and complementary to textual sources, where they exist.[85] It is as illustrations of changing surgical practice that instruments are still used by most medical historians,[86] and very often the danger is that they are unable to comprehend fully the exact nature of the instruments themselves.

[82] Coppa *et al.* 2006: 755-756.
[83] Lukacs and Pastor 1988: 377-398.
[84] Harappa, E3 No. 1; National Museum, New Delhi, inv. No. E3/2600, also known as a toiletry gadget, *Harappa*: 390, pl. CXXV.1. There are strong parallels with similar sets found at Ur and Kish and dated to the Early Dynastic III period (Mackay 1929: 169, pl. XLIII.1-8; Woolley 1934: pl. 159b). See also Gregory L. Possehl 2002b: 325-328, fig. 3.
[85] Lawrence 1992: 295.
[86] Lawrence 1992: 295-206.

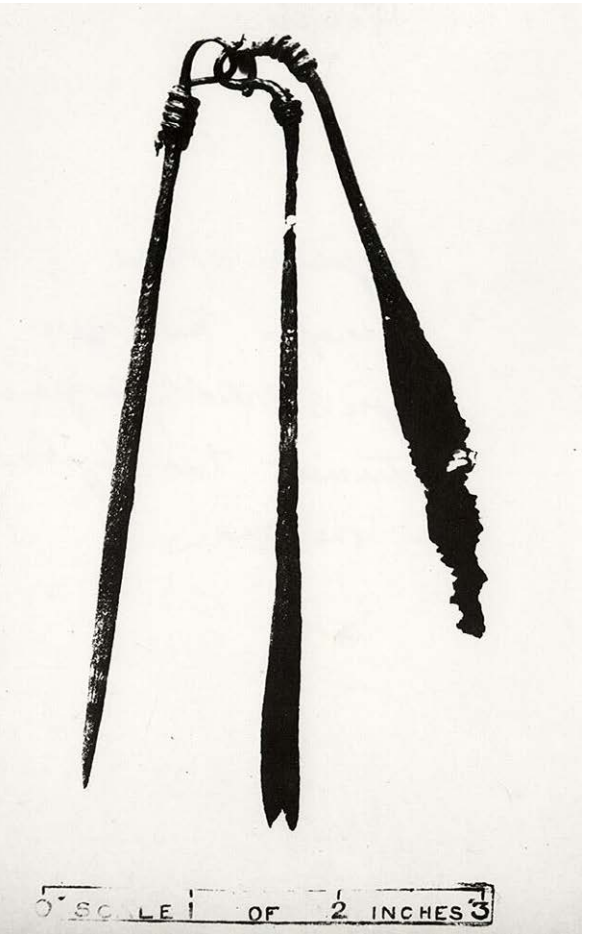

Figure 15. Joined spatula or toiletry gadget from Mound AB Harappa; Mature Harappan Phase; Harappa E3 No. 1. National Museum, New Delhi (E3/26000).

For those engaged in the study of the prehistory of medical practice, new developments in bioarchaeology have meant that what are believed to be surgical instruments can now be subjected to analytical study, such as organic residue analysis; but this is the limit of direct inference and other deductions rest on another branch of archaeological study, that of analogy with societies already known to us.[87] However, this process in the study of surgical instruments, as pointed out in the introduction, has a number of difficulties attached to it; particularly that if, by analogy, an ancient instrument, based on our inspection, appears to have been surgical, and to the eye of a modern surgeon or medical historian it is capable of being used in surgery, however primitive, then the surgical processes must have been the same, or the instruments used in a certain way.[88] In reality, our true understanding of the remote past is so incomplete

[87] Lawrence 1992: 296.
[88] Lawrence 1992: 297.

that it is likely that in some societies surgery is indistinguishable from other acts, ritual or otherwise. Any view on the actual surgical use of ancient instruments, without corroborative textual records, is of course, based upon informed speculation.[89]

Bandages

Bandaging is a natural instinctive action in the treatment of wounds. In the Indus Civilisation, wool and cotton were both freely available and used by many different layers of society and would have been used for making bandages. It is possible that they started the cultivation of cotton as a response to a need, which products made from animal hair, hides and other plant fibres could not fulfil, including bandages. Many of the bandages used in contemporary societies were made from linen (not native to India), but there is no evidence of the importation of linen into the Indus region,[90] although it is found in the Gulf at the time, a region with which the Harappans had close trading relations.[91]

Wads, surgical dressings, and tapes would also have been manufactured from wool and cotton bandages used for covering and keeping in place external medication and mechanically retaining in position and protecting whilst healing ruptured tissue or broken or dislocated bones. Probably unguents were applied with lint, often made from vegetable tissue or cotton waste, itself either a vehicle for the remedies, or an absorbent of blood and secretions. They were probably fashioned into plugs for use as swabs, or even would be used for securing splints. It is also likely that the suturing of wounds was practised, although there is no immediate evidence as no soft tissue survives. They would also have been supported by medicinal preparations, made mostly from plants.

Bandages made from linen, were certainly used in treatment in ancient Mesopotamia,[92] and it is speculated that several drugs were added to the dressing before its application to the patient (and being replaced when necessary), not to forget their use in Egypt for mummification.

The *Materia Medica*

The ingredients of medical remedies, the *materia medica* of the Indus Civilisation, is believed to have been derived largely from plants and their fruits, wine and honey, and a few animals and their products. Some minerals may also have been used but were likely of secondary importance. The trade between the Indus Civilisation and the Near East and the Iranian Plateau may have included plants and minerals, although this cannot yet be confirmed by the evidence. Of these plants, a number would have been imported or exported and then cultivated locally. It is speculated that many were for medicinal uses. It is also quite possible

[89] A good example of where texts meet archaeology is with tablet (UT 2050) found at the Syro-Palestinian city of Ugarit (Ras Shamra), dated roughly to 1500 BC. It contains a list of instruments and equipment that belonged to a physician (*asû*) named *Krw*. Itemised in the list are several surgical instruments and pharmaceutical manufacturing objects, including a whetstone, sheathed forceps, scalpels, and lancets. Stieglitz (1981: 53) believes that the forceps (*mqhm*) were likely used in the preparation of medication, which may require heating, but may also have been used in surgery as haemostatic forceps. The use of a sheath would favour such an instrument, since it is most likely to be sharp, requiring a cover, see Stieglitz 1981: 53.

[90] Fairservis 1971: 291.

[91] Reade and Potts 1993: 103. Linseed or flax (*Linum usitatissimum* L.) is recorded from Sanmghol and Shortughai.

[92] Adamson 1991: 428.

that the trade was dominated not by plants but by medicinal preparations, which have not survived.

While plant-based therapeutics may, on reflection, have been pharmacologically sophisticated, those who made these remedies were unlikely to have had any expert knowledge of their exact properties, which probably arose from folk-discovery. From experience, they would have had a clear idea of their effectiveness, but would have been discriminating in their use, for these remedies required very careful preparation to produce a concentration that was therapeutically effective but non-toxic; many of them may have been dangerous if taken in wrong doses.

The accurate dispensing of medicines can require the use of weights and measures and work on petrology in the Indus Civilisation points out that by the time of the mid 3rd millennium BC a sophisticated system would have existed (Figure 15). This also infers that the creation of a weight standard reflects a 'currency value' of a commodity, in this case prepared remedies or their ingredients.[93]

Healers with their herbal remedies would have used them to sooth and reduce pain, dry secretions, treat dermatological ailments, and hasten healing. As in many ancient societies, the most common use of herbal remedies would be to treat gastrointestinal and respiratory ailments. Some would have produced the desired effect, especially in the case of emetics, purgatives, and expectorants. Some would have been taken internally; others applied externally as a poultice, or even inhaled.

A good many herbal remedies were probably pharmacologically ineffective and had an effect limited to that of a placebo. It is known that a combination of simple domestic remedies and an element of magic, whereby these remedies then form part of a magical procedure, is the common characteristic of most primitive medicine and the tradition of self-help in medicine must have been strong, particularly in the countryside.

They would have had several local herbs at their disposal, as well as being able to take advantage of others that were imported. John Nunn has described the collection, preparation and dosage of remedies used in ancient Egypt,[94] and although there is not yet any similar textual evidence for the Indus Civilisation, it is possible to speculate that many of the procedures would have been rather similar.

Plant Remedies

Many of the flowers and plants pictorially represented on Indus Civilisation art are connected, both positively and apotropaically, with fertility and the promotion of life, or with the prevention of death. One could also argue for the centrality of the plant in religious beliefs and activities and that the plant can take on the quality of sanctity as well as naturally being central to both food and survival. The richness and variety of plant life and its importance for human beings is reflected in the pictures of Harappan cult scenes.

[93] For Indus Civilisation metrology, see Ratnagar 2003: 79-92; *Trading Encounters*: 246-255.
[94] Nunn 1996: 138-143.

Many varieties of plant life are depicted and it appears that different plants were vividly perceived for their different qualities. Although any plant cult would naturally have been associated with fertility, it is quite possible that such a cult could also centre on a plant's healing properties.

There have been problems in identifying the remedies which were in use by the Indus Civilisation and in making a distinction between plants used as remedies and those employed in the kitchen or elsewhere. Because of the lack of documented remedies and their prescriptions, it is only possible to speculate which of the many plants or prepared herbs and spices, either home-grown or imported, would have been prized for their medicinal properties, the speculation based tentatively on what is known of their medicinal application in the Near East.[95] Naturally, some remedies or popular therapeutics would, of course, have been made up from local ingredients and used domestically. The evidence from environmental recovery on archaeological sites, for the collection and use of plants that have potential medicinal properties, is relatively limited. However, it is possible to piece together from this evidence knowledge of wild and cultivated plants that would have been gathered, possibly for medicine, but certainly for food or other uses.

Bhang or hemp (*Cannabis sativa* L.), a native to India and still found in abundance, was known by that time. Some of the evidence comes from the site of Kunal, where seeds of hemp, cultivated for its tough base fibres used for sacking and sailcloth, have been recovered. The dried flowering tops of the pistillate plants can be used medicinally, being both sedative and analgesic. However, the discovery of its psychotropic qualities may not have happened until much later and the drug cannabis does not appear in the Ancient Near East, for example, until the second quarter of the 1st millennium BC.[96]

The headdress of Queen Pu-abum found in one of the graves of the Royal Cemetery at Ur (PG800) has included within it the imitation in gold of the leaves of the **sisso tree** (or Pakistani rosewood) (*Dalbergia sisso* Roxb.),[97] a large tree with grey bark, native of north-western India and as far west as Eastern Iran. Its earliest archaeological attestation comes from Mehrgarh III (mid 5th millennium BC). While its wood was mainly used for construction work and the production of objects such as handles and tools, its oil and leaves are also known for their medicinal properties. Sisso oil kills the larvae of and repels mosquitoes[98] and its leaves are anti-diarrhoeal,[99] anti-inflammatory,[100] analgesic and antipyretic.[101]

The position of the **neem** (*Melia Azadirachta* L. or *Azadirachta indica* A. juss), **pipal** (*Ficus religiosa* L.), and **acacia** (*Acacia catechu* Willd.) is central to Indus medicine. **Neem** is among the most exploited of medicinal plants of Indian origin. All parts of the plant have some biological and medicinal properties, hence it is a valuable source of natural medicinal products. Compounds

[95] Herrero 1984; Campbell Thompson 1924, but caution is advised on the use of this work, as many of his identifications depend on what we now know to be dubious etymologies. Of course, a parallel medicinal use of a plant in different culture does not, of course, prove that they learned from each other. The effects of plants will have been learned by independent observation.
[96] Barber 1991: 38.
[97] Tengberg *et al.* 2008: 925-936.
[98] Ansari 2000: 207-211.
[99] Brijesh *et al.* 2006: 120-124.
[100] Hajare *et al.* 2001: 131-139.
[101] Hajare *et al.* 2000: 357-360.

isolated from neem are broadly classified into two: (a) Isoprenoids; and (b) Non-isoprenoids. Isoprenoid compounds consists of diterpenoids, triterpenoids and steroids, while non-isoprenoids contain proteins and include ammo acids, polysaccharides and flavonoids. It is found beneficial in the treatment of, or relief from, leprosy, gastro-intestinal problems, malaria, intestinal helminthiasis, tuberculosis, ringworms, skin disorders, boils, epilepsy, fever, respiratory distress, nausea, ulcers, and many other conditions.[102] **Henna** or Mehendi (*Lawsonia intermis* L.) has been identified at Rohira. An evergreen shrub, it is used medicinally to treat wounds, sores, and skin infections; it is gargled for a sore throat and can be taken internally for diarrhoea, dysentery, stomach ulcers, tapeworm, and has known antibacterial, antifungal, and antheminthic properties. **Linseed** or flax (*Linum usitatissimum* L.), with its delicate blue flowers, is recorded from Sanmghol and Shortughai. Apart from the possible use of flax fibres in the textile industry, linseed oil – pressed from flax seeds – has medical applications. Used for poultices it can also be taken as a primitive purgative. There is evidence of the **pomegranate** (*Punica granatum* L.) from the site of Banawali. Known principally as a food, its finding is problematic as it is thought to originate in south-east Europe. However, is has known antidiarrhoeal and antheminthic properties.

The site of Sanghol has produced evidence of the **opium poppy** (*Papaver somniferum* L.), which produces one of the most powerful and important drugs at the time. Opium, known for thousands of years, contains the alkaloid components noscapine, thebaine, narcene (a hypnotic), narcotine, morphine, codeine, and papaverine, many of which are classical pharmacological agents. Obtained by incising the unripe capsules of the opium poppy, it is unknown in a truly wild state, and is thought to be a derivative of the poppy and first cultivated presumably for its oil-containing seeds. Some believe that the Near East is the home of the earliest and best wild varieties of the plants.

Opium is the congealed latex derived from the juice of the unripe capsules. It contains more than thirty alkaloids, of which morphine and codeine are the most widely used for medicinal purposes. Having made fine slits on the outer surface of the capsule, taking care not to pierce the interior, the exuded juice is collected next day by scraping it off the cut surface, squeezing it into small lumps and then leaving to dry. The capsules are capable of yielding opium only for a very short period (nine to 15 days) after the flowers have fallen, and before they ripen and dry. Wild poppies produce the more potent latex.

Raw opium, as well as having powerful psychotropic effects, is a well-known analgesic and sedative, with properties to allay pain and induce sleep, with a maximum content of anhydrous morphine of 20% (minimum 9.5%). It is possible, for example, that an extract of opium applied directly to a wound might be absorbed in large enough amounts to have the same effect as morphine; while a piece of wool soaked in a solution of opium and a little saffron, would have been effective if used as a suppository to alleviate internal pain. It may also have been used as an anaesthetic in primitive surgery, or in community medicine as a sedative for soothing teething babies by rubbing it into their gums.

[102] Tiwari *et al.* 2014: 110-123. More recent research shows that Azadirachta indica A. juss (neem) is one of the most useful medicinal plants having preventive functions against a wide range of diseases. Extracts obtained from different parts of the neem tree (leaves, flowers, seeds, bark, roots) contain numerous bioactive phytochemicals which are known to have therapeutic potentials. Extensive studies demonstrate that these bioactive compounds of neem have different properties that have therapeutic effects on inflammation, apoptosis, angiogenesis, immunomodulation, and a wide range of diseases. See Sarkar *et al.* 2021: 178.

Raw opium's analgesic properties result mostly from its morphine content, which acts as a depressant on the sensory cortex and the respiratory centres; other alkaloids of the opium, especially codeine, have a stimulant action on the medulla and spinal cord; papaverine and noscapine relax intestinal muscle.

Ayurvedic medicine from the 1st millennium BC and later utilises many different plants with effective properties, indigenous to South Asia and that may have been in use millennia earlier. Some examples include **coriander** (*Coriandrum sativum* L.), an annual umbelifier cultivated for its aromatic seeds, whose therapeutic effects are well-known. The fruit may be used as a stimulant and carminative;[103] it has a cooling effect when applied on bread as a poultice for external ulcers. The seed, dried and mixed with a little raisin wine, is believed to cure internal parasites; the powdered fruit, fruit extract, and oil can be used medicinally for flavouring active purgatives and to correct their griping tendencies.

There is also **cumin** (*Cuminum cyminum* L.), an annual umbelliferous herb, whose seeds are a stimulant and carminative used in treatments, amongst others, for digestive and bladder ailments, headaches, menstrual disorders, and as a mild painkiller. It was also an ingredient of a poultice applied after an enema for perianal disease. Externally, it was also often prescribed for treating abscesses, skin ailments, burns, and, when chewed, for disorders of the mouth. One of its early uses was for eye poultices and insect stings. As well as in the kitchen, **dill** (*Peucedanum graveolens* Benth.) could be used medicinally – its oil can be used as an aromatic carminative, especially in the treatment of flatulence in infants. **Fennel** (*Foeniculum vulgare* Gaertn.), a strong-smelling glaucous perennial, with aromatic seeds and tender shoots, is found throughout the region. The oil produced by the seed has distinctive medicinal properties. Like others, fennel oil is an aromatic and can be given to infants to as a carminative and diuretic and may have been used an antidote for snake bite.

The **saffron crocus** (*Crocus sativus* L.) is of the iris family *Irideae* and its bright red stigma – saffron – was harvested from its flowers, highly valued for flavouring foods and possibly as a wine colorant, as well as in dyeing textiles and perfumed oil industries; it can also be used for pharmaceutical purposes, i.e. as an important sedative; specifically, it can be used to ease menstrual and obstetric pain and is also known as an effective medication for stopping chronic haemorrhage of the uterus. **Sage** (*Salvia officinalis* L.) is a strongly aromatic shrub and one of the most important medicinal herbs in antiquity. It can be used, as sage oil, as a diuretic, when mixed with white wine, as a treatment for pains of the spleen, dysentery, and it also has a gynaecological use, i.e. to help stop bleeding.

Mineral Remedies

Not only plant-based, but also, to a lesser extent, mineral-based remedies will have been in use during the period. Numerous remedies of mineral origin were used in ancient Egypt,[104] and many of them (e.g. alabaster, common salt, alum, ochre) are naturally available in the Indus Valley and may have had similar medical uses. These substances were obtained by heating, leaching, or pounding the mineral from the rock deposit, particularly crystalline alum. A solution of alumen,

[103] Wren 1956: 95.
[104] Nunn 1996: 145-148.

or alum and water, can be used medicinally when mixed with honey as an effective salve for mouth ulcers and for many different skin complaints.

Ancient Egyptians knew of its medicinal use as an ingredient of an ointment in a local remedy against the swelling of a tumour and generally as a valuable astringent and haemostatic. Specific examples of its use are as a remedy against the discharge of a tumour (now thought to be leprosy), as a component of a mixture to treat fever, and as a remedy against the eye disease trachoma.[105] Alum was also known to the Indus Civilisation.

Marshall also refers to the finding at Mohenjo-daro (DK and VS Areas), in small quantities, of a substance called śilājīt or ***shilajit*** (Sanskrit, meaning 'exuding from the rocks') or asphalt, black in colour, exuding from rocks in the Himalayas. It is hard when dry and when placed in a solution of water turns into a dark brown solution. Today, the name is given to two substances: one, white in colour, is pure aluminium sulphate; the other, black, is śilājīt, which is quite different and can be identified with the substance found at Mohenjo-daro. A bituminous alum ore, often with vegetable matter mixed in with it, it is still in use today in Ayurvedic medicine. Its composition, however, is still not well understood, but it has been reported to contain at least 85 different minerals, including triterpenes and aromatic carboxylic acid, as well as humic and fulvic acids. It is believed to be valuable in the treatment of the liver and spleen, dyspepsia, diabetes, joint pain, and also helpful in the regulation of the heart, a good respiratory stimulant, and an expectorant.[106] Copper-based ointments, a known bactericide, may also have been used in the treatment of wounds.

Animal Product Remedies

In a society whose economy was dominated by animal husbandry, it seems likely that animals would have been used medicinally, with remedies likely deriving from organs, blood, faeces, horn, skin, fat, etc. Marshall refers to the finding at Mohenjo-daro of stag horns from four different kinds of deer: the **Kashmir stag** (*Cervus cashmerianus*), the **sambar deer** (*C. unicolor*), the **spotted deer** (*C. axis*), and the **hog-deer** (*C. porcinus*), which he suggests were a commercial commodity, particularly as they had to be imported long distances from the north; the hog-deer the only one being native to the Indus region. When the horns (and possibly the bones) were ground down, the resulting powder could then be used for medicinal purposes. Marks on the horn suggest that they were cut into small pieces for grinding.[107] There is some evidence for the medical use of the horn of the sambar deer; at Chandu-daro these horns were found, with cut marks, in a building which may have been a pharmacy.[108]

Finds of **cuttlefish** (*Sepia officinalis*) bones in domestic pottery vessels suggest that they were used for their medicinal value. Cuttlefish bone refers to the internal cartilaginous shell of the cuttlefish, a relative of the squid and octopus. Cuttlefish bone is typically smooth and white,

[105] von Deines 1958: 239.
[106] *Mohenjo-daro*: 29, 587, 690 (Appendix I for analysis). Marshall refers to its identification by Sana Ullah, the then chemist of the Archaeological Survey of India. Its medicinal properties are explained by Dr Hem Chandra Sen in the *Indian Medical Record*, 14 and 21 May 1902. See also Nadkarni 1954: 23-32. For the medicinal properties of *shilajit*, see the website *Alakananda Ma, Shilajit: conqueror of the mountains and destroyer of weakness*, 2012, http://www.alandiashram.org/gurukula_blog/2012/03/shilajit-conqueror-of-the-mountains-and-destroyer-of-weakness.html.
[107] *Mohenjo-daro*: 669, 671-672.
[108] *Chanhu-daro*: 53.

with small, wavy lines or ridges. The shell is rich in minerals such as calcium and carbon and contains more than a dozen amino acids. It is usually boiled, then dried and prepared as a powder for herbal remedies. In alternative medicine, cuttlefish bone has salty and warm properties and is associated with diseases of the kidneys, liver, and stomach meridians. Its functions are to stop bleeding, harmonise the stomach, and improve kidney deficiency. Internally, it is taken to help stop bleeding of the uterus, enuresis, and premature ejaculation. Some patients with stomach problems may take it to combat disorders of the upper and lower digestive system. Topically, cuttlefish bone can also be used as a poultice to treat skin rashes, ulcers, and lesions.

Food and Drink

Some everyday foods and drinks may also have had medicinal uses. **Honey** (often mixed with beeswax), for example, may well have been available; it was certainly used by ancient Egyptians for many medical purposes, i.e. as an unguent for dressing wounds, in salves for treating eye-disease, and as a sweetener in purgatives. It can be used as a sedative in obstetrics[109] and is also a known natural antibiotic.[110] A salve made with one part honey and two parts grease (olive oil or animal fat) has the properties of being non-toxic, aseptic, fungicidal, antiseptic, and antibiotic. As a salve, honey does not damage tissues and attracts moisture to prevent bandages from sticking to wounds. Clinical tests have proved that honey speeds up the healing process in a wound.[111]

At the sites of Rohira, Shortughai, and Balu there is evidence of the growing of grape vines. The **grape** (*Vitis vinifera* L. ssp. *vinifera*) has been identified as part of the Harappan crop assemblage. It is a non-native crop, arriving in the Indus Valley *c.* 3200 BC, and has thus been used to argue as evidence for long-distance trade and the adoption of foreign agricultural practices.[112]

Whether the Harappans made wine is not clear, but if they did it may also have been used as a wound cleanser. We know that wine (containing a polyphenol) is bactericidal and research has shown that a 50% wine/water mixture kills cholera vibrios within 10 to 15 minutes, and typhoid bacilli disappear within 24 hours, although this property was probably not understood at the time. Wine's bactericidal power also increases with age and can be used as an antiseptic[113] and in many prescriptions, i.e. a vaginal enema to help arrest metrorrhagia. Beyond food and a beverage, the medicinal property of wine has a history for the external treatment of several conditions including swellings, boils, rheumatism, and back pain.

[109] von Deines *et al.* 1958: 47-50. Honey was used in 500 out of 900 known prescriptions in ancient Egypt, see Nielsen 1993: 415-419.
[110] Bergman *et al.* 1983: 374-376. The anti-bacterial qualities of honey derive from its hygroscopic nature (thus desiccating bacteria) and its enzyme inhibine, which converts glucose and oxygen to the disinfectant hydrogen peroxide and the mild antibiotic glucono-lactone. Internal use on children with gastro-enteritis shortened the duration of diarrhoea, see Haffjee and Moosa 1985: 1866-1867.
[111] *Healing Hand*: 116-117.
[112] Bates 2021; Khare 2007.
[113] *Healing Hand*: 186-188.

Other Therapeutics

There is little evidence for other forms of therapeutics. Spring waters may have been considered to have therapeutic effects; water is the symbol of life and spring water may have been considered as a gift from the gods, as was city-based bathing. As for the treatment, if any, for diseases such as rickets, the obvious therapy is dietetic, with a vitamin D enriched diet and the abundance of fresh air and sunshine. However, one wonders whether the economic causes for some of the rickets in the first place, e.g. children working in sweatshops, would have taken priority over its cure or, as already referred to, it may be the result of long and continuous sandstorms, in places like the Sind desert, which can block out the sun for months on end, affecting the quality of life.

Chapter Seven

Epilogue

This book offers those who study the Indus Civilisation, or study disease and medicine in the ancient world, a synthesis of what we know of health, healing, medicine, and disease of the population, and is an attempt at defining new areas of research that should be addressed. As Kennedy has reminded us, South Asian scholarship in the field of the study of human remains can now offer new answers to old questions about the origin and antiquity of the earliest hominids in the subcontinent and the beginnings of the Indus Civilisation, as well as the demographic profiles that include health and disease status, traumatic and developmental modifications, population sizes, and densities.[1]

Answers are now beginning to emerge, modifying earlier theories and interpretations of archaeological and osteological data. These include, for example, a confirmation that hominids, having earlier migrated from Africa, were present in the north-western sector of the subcontinent during the geological period of the Pliocene-Pleistocene transition, and that the roots of the Indus Civilisation lay in Neolithic cultures by 7000 BC, long before urban settlement. It has also been possible to reject myths concerning the origins of the Aryans, and recent work has made it possible to re-evaluate population genetic affinities using aDNA and isotope analysis.[2]

In the wider field, we also know that the major urban centres of the Indus Civilisation in its Mature Harappan Phase, while having developed a complex social order, with well-defined occupational structures, were also pastoralists and maintained large cattle herds, from which zoonotic diseases could have spread and would have had a devastating impact. Unlike malaria, they needed no vectors, transmitting themselves from human to human both readily and rapidly. Although some immunity would develop amongst infected populations, the incessant outreach of civilisation meant that traders and seafarers would inevitably have bridged pathogen pools, spilling diseases onto virgin soil. The endemic disease of one society would become another's epidemic, as trade and travel defined the spread of lethal pathogens that caused both mortality and morbidity on a large scale.

Large urban centres, such as Mohenjo-daro and Harappa, will have assumed decisive roles in the spread of disease, being magnets for pathogens, as well as people seeking refuge, work, and better lives. Some cities could have been so unhealthy that periodically they were unable to replace losses from disease by new births; they grew only because of the influx of surplus rural populations, themselves often infection prone. Only sturdy urban survivors would have turned into a new immunological elite; their virulently infectious environment would have become perilous to newcomers. Having said that, the evidence we have of Falciparum malaria,

[1] Kennedy 2003: 352-367. Sadly, Ken Kennedy died as I was writing this book; I remember him for his generosity and help.

[2] For review of new scientific work on aDNA and isotope analysis, see *Bioarchaeology*; Shinde *et al.* 2019: 729-735; Narasimhan *et al.* 2019.

suggests that it may have been a major problem to that society, not only clinically but also socially, creating a micro-environment that would occasionally inhibit social development.

The Indus Civilisation flourished due to many factors, important among them being the prevalence of the congenial climatic conditions, the availability of the fertile plains of the Rivers Indus and Ghaggar-Hakra to grow food, and eventually surplus trade with the Gulf and Mesopotamia. However, what we know today is mainly the history of their urban life, as comparatively very few rural Indus settlements have been excavated systematically on any large scale. On any future agendas, if we are to understand about disease and health we must get to know much more about rural life, but it is not known if any had cemeteries.

We now know at least something about Indus Civilisation disease, health, medicine, and their remedies and surgery. Perhaps when the Indus Script is finally deciphered, the texts might possibly offer us something. Like the discovery of more human skeletal remains and the detailed publishing of many that have already been excavated, this is awaited with a great deal of anticipation. The evidence of health, disease, trauma, and burial customs, particularly from Harappa, points to a new understanding of the Indus Civilisation. This is mostly through the application of bioarchaeology and is revitalising this understanding. It is the future.[3]

Researchers have more recently turned to aDNA analysis to attempt to identify the pathogens responsible for infectious disease in the past. Claims have been made for the identification of malaria, tuberculosis, and leprosy in skeletal remains, but it should not be assumed that these scientific advances, when applied to Indus Civilisation skeletal remains, will always produce results. Poor preservation remains a serious impediment, but it is also the case that caution may be exercised in selecting samples, diseases, and disease markers for analysis. Samples from an individual with leprosy from Balathal have been sent for analysis of pathogen DNA at three separate laboratories that specialise in genetic and genomic analyses, but only negative results have been obtained.[4]

There is something very special about the Indus Civilisation, particularly those unique aspects that characterise it and its material culture, with its astonishingly homogeneity, undisturbed by a huge geographical expanse which by far exceeds any other Bronze Age culture in the Old World.[5] That we also know something about their health and disease is equally as important, but from the evidence we have of the health of the population of Indus cities, while it is accepted that it was egalitarian, the concept of a completely healthy and happy society is perhaps an illusion. What I do not want to do is change in any way the paradigm we have for the Indus Civilisation, but simply to make readers aware of the reality of both urban and rural life.

The very last word and a reinforcement of the challenge facing scholarship in our field of study, must go to Possehl, who summed up the huge gap in our knowledge of the Indus Civilisation with the words:

[3] Robbins Schug 2017: 281.
[4] *Bioarchaeology*: 171.
[5] Lamberg-Karlovsky 1999: 87.

> '... [we] do not know what these people called themselves or their cities... we have no king lists, no internal chronology... no historical account of commerce, production... no historical record of the internal social organisation...'[6]

To discover all of these is amongst the ambitions of the civilisation's archaeologists and epigraphists. As far as their health and medicine is concerned, hopefully, this book goes a very small way to helping fill that lacuna.

[6] Possehl 1990: 262 (quoted in Wenke and Olszewski 2006: 405).

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